NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

CATALOGUE FOR 1974–1976

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MONTEREY, CALIFORNIA

CATALOGUE FOR 1974–1976

POLICY

The Secretary of the Navy has stated the following policy on graduate education for U.S. Navy and U.S. Marine Corps officers:

"Raise the educational base of our officers.

"Increase by undergraduate full-time study or by off-duty study, the numbers of officers qualified for graduate education.

"Encourage voluntary application for graduate education.

"Order to advanced education as many qualified officers as possible to meet the Navy's and Marine Corps' requirements for graduate education.

"Utilize the graduate education of individuals whether obtained in off-duty study, in tuition aid programs, in government fully-funded programs, or however obtained, giving due attention to the broad professional experience which supplements the officer's educational background.

"Insure that performance in all duty assignments is the primary criterion for promotion. Emphasize to all officers that graduate education coupled with outstanding performance will enhance an officer's chances for promotion. Selection boards must recognize this as a potent factor in judging the career performance of officers considered for promotion."

MISSION

The Secretary of the Navy has defined the mission of the Naval Postgraduate School as follows:

"To conduct and direct the Advanced Education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence."

Superintendent

ISHAM WISEMAN LINDER

B.S., U.S. Naval Academy, 1946

M.S.E.E., Naval Postgraduate School, 1956

Ph.D., University of California at Berkeley, 1961

Academic Dean

JACK RAYMOND BORSTING

B.A., Oregon State University, 1951;
M.A., University of Oregon, 1952; Ph.D., 1959

BOARD OF ADVISORS

The NPS Board of Advisors is a distinguished group of civilian educators, business and professional men. The Board visits the campus periodically to examine educational programs, recommend improvements and discuss plans and problems with the Superintendent. Present members are:

Dr. Ralph D. Bennett, Independent Consultant

Rear Admiral William A. Brockett, USN (Ret), President, Webb Institute of Naval Architecture

Mr. Richard R. Hough, President, American Telephone and Telegraph Long Lines

Dr. Neil H. Jacoby, Graduate School of Management, University of California at Los Angeles

Admiral I. C. Kidd, USN, Chief of Naval Material, Navy Department

Dr. Hans M. Mark, Director, NASA Ames Research Center

Provost George J. Maslach, Professional Schools & Colleges, University of California at Berkeley

Dr. Dean E. McHenry, Chancellor, University of California at Santa Cruz

The Honorable David S. Potter, Assistant Secretary of the Navy (Research & Development), Navy Department

Admiral James S. Russell, USN (Ret), (Board Chairman), Consultant, Boeing Aircraft

Mr. Emmett G. Solomon, Chairman of the Board, Crocker Bank

Chief of Staff

EARL FRANCIS GODFREY
Captain, U. S. Navy
B.G.S., University of Nebraska, 1972
Naval War College, 1955
National War College, 1968

Director of Programs

DONALD WALTER KILEY
Captain, U. S. Navy
B.S., Naval Postgraduate School, 1954
Aeronautical Engineer, California Institute of Technology, 1955
Naval War College, 1962

Director of Military Operations and Logistics

EDWARD EVERETT RILEY
Captain, U. S. Navy
B.S.M.E., University of Missouri, 1969
Air Force War College, 1966

Dean of Programs

WILBERT FREDERICK KOEHLER
B.S., Allegheny College, 1933; M.A.,
Cornell University, 1934; Ph.D., Johns Hopkins University, 1948

Deputy Director of Programs

KENNETH ALBERT HORN
Captain, U. S. Navy
B.S. University of Michigan, 1952
B.S.A.E., Naval Postgraduate School, 1960

Dean of Curricula

BROOKS JAVINS LOCKHART
B.A., Marshall University, 1937; M.S., West
Virginia University, 1940; Ph.D., University of Illinois, 1943

Dean of Research

Registrar

MISS EDITH JEAN WARRINER
B.A., Occidental College, 1947

SUPERINTENDENT'S STAFF ASSISTANTS

Aide to the Superintendent ..... LT Nathan Howard Beason, USN
Comptroller ..... CAPT Orrin Bowen Ross, SC, USN
Civilian Personnel Officer ..... Mr. Weston Burton Lockwood
Public Affairs Officer ..... LCDR Paul Conners, USN

PROGRAMS ADMINISTRATIVE STAFF

Plans Officer ..... CDR Richard Joseph Brennan, USN
Flight Officer ..... CDR Stanley Briggs, USN
Administrative Officer ..... CDR Barbara Jane Suse, USN
Academic Assistant ..... ENS Margrette Carr Gebeaux, USN
Foreign Training Officer ..... CDR Eugene James Normand, USN
Marine Corps Representative ..... LTCOL Russell Edwin Jamison, USMC
Submarine Liaison Officer ..... LCDR Samuel Dell McLeod, Jr., USN

MILITARY OPERATIONS AND LOGISTICS STAFF

Director, Administration Dept. ..... CDR Dale Allen Meyer, USN
Director, Supply Dept. ..... CDR Donald Abner Beals, SC, USN
Director, Public Works Dept. ..... CDR Ralph Michael Cerreta, CEC, USN
Director, Medical Department ..... CAPT Albert Davis Nelson, MC, USN
Director, Dental Dept. ..... CAPT Maury Emerson Wortham, DC, USN
Deputy Director of Military Operations and Logistics CDR Ernest Fischbein, USN
Catholic Chaplain ..... CAPT Joseph Emmet Ryan, CHC, USN
Protestant Chaplain ..... CAPT William Roy Samuel, CHC, USN
Legal Officer ..... LT John Terrence Porter, JAGC, USNR
Communications Officer ..... LTJG Vicki Rene Love, USN
First Lieutenant ..... LCDR Robert Eugene Delashmitt, USN

CALENDAR FOR 1974-75 ACADEMIC YEAR

1974

Registration for IGEP, Administrative Science Curricula .....Monday, 1 July
Fourth of July (holiday) .....Thursday, 4 July
Quarter 1 Begins (1974-75) .....Monday, 8 July
Labor Day (holiday) .....Monday, 2 September
Registration for all Curricula except Administrative Science,
Ops Sys Tech ASW) .....Monday, 23 September
Examination Week for Quarter 1 .....23-27 September
Final Date for Completion of Thesis for September
Graduation .....Wednesday, 25 September
Quarter 1 Ends .....Friday, 27 September
Graduation .....Friday, 27 September
Quarter 2 Begins .....Monday, 30 September
Columbus Day (holiday) .....Monday, 14 October
Veterans Day (holiday) .....Monday, 28 October
Thanksgiving Day (holiday) .....Thursday, 28 November
Examination Week for Quarter 2 .....16-20 December
Final Date for Completion of Thesis for December
Graduation .....Wednesday, 18 December
Quarter 2 Ends .....Friday, 20 December
Graduation .....Friday, 20 December
Christmas (holiday) .....Wednesday, 25 December
Registration for IGEP, Administrative Science CurriculaMonday, 30 December

1974

JANUARY

S	M	T	W	T	F	S
..	..	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	..	..

FEBRUARY

S	M	T	W	T	F	S
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10	11	12	13	14	15	16
17	16	19	20	21	22	23
24	25	26	27	28	..	..

MARCH

S	M	T	W	T	F	S
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10	11	12	13	14	15	16
17	16	19	20	21	22	23
24	25	26	27	28	29	30
31	..	..	..	..	..	..

APRIL

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MAY

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12	13	14	15	16	17	18
19	20	21	22	23	24	25
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JUNE

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16	17	18	19	20	21	22
23	24	25	26	27	28	29
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JULY

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14	15	16	17	16	19	20
21	22	23	24	25	26	27
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AUGUST

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11	12	13	14	15	16	17
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25	26	27	28	29	30	31

SEPTEMBER

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14	15	16	17	18	19	20
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OCTOBER

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20	21	22	23	24	25	26
27	28	29	30	31	..	..

NOVEMBER

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10	11	12	13	14	15	16
17	16	19	20	21	22	23
24	25	26	27	28	29	30

DECEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	16	19	20	21
22	23	24	25	26	27	28
29	30	31	..	..	..	..

1975

New Years Day (holiday) .....Wednesday, 1 January
Quarter 3 Begins .....Monday, 6 January
Washington's Birthday (holiday) .....Monday, 17 February
Registration for all Curricula except Administrative Science,
Engr Acoustics, Naval Intelligence .....Monday, 24 March
Examination Week for Quarter 3 .....24-28 March
Final Date for Completion of Thesis for March
Graduation .....Wednesday, 26 March
Quarter 3 Ends .....Friday, 28 March
Graduation .....Friday, 28 March
Quarter 4 Begins .....Monday, 31 March
Memorial Day (holiday) .....Monday, 26 May
Examination Week for Quarter 4 .....16-20 June
Final Date for Completion of Thesis for June Graduation Wednesday, 18 June
Quarter 4 Ends (1974-75) .....Friday, 20 June
Graduation .....Friday, 20 June

1975

JANUARY

S	M	T	W	T	F	S
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12	13	14	15	16	17	18
19	20	21	22	23	24	25
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FEBRUARY

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16	17	18	19	20	21	22
23	24	25	26	27	28	..

MARCH

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23	24	25	26	27	28	29
30	31	..	..	..	..	..

APRIL

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20	21	22	23	24	25	26
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MAY

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18	19	20	21	22	23	24
25	26	27	28	29	30	31

JUNE

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15	16	17	18	19	20	21
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JULY

S	M	T	W	T	F	S
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AUGUST

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17	18	19	20	21	22	23
24	25	26	27	28	29	30
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SEPTEMBER

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14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	..	..	..	..

OCTOBER

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12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	..

NOVEMBER

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23	24	25	26	27	28	29
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DECEMBER

S	M	T	W	T	F	S
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14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	..	..	..

CALENDAR FOR 1975-76 ACADEMIC YEAR

1975

Registration for IGEP, Administrative Science Curricula .....Monday, 30 June
Fourth of July (holiday) .....Friday, 4 July
Quarter 1 Begins (1975-76) .....Monday, 7 July
Labor Day (holiday) .....Monday, 1 September
Registration for all Curricula except Administrative Science
Ops Sys Tech (ASW) .....Monday, 22 September
Examination Week for Quarter 1 .....22-26 September
Final Date for Completion of Thesis for September
Graduation .....Wednesday, 24 September
Quarter 1 Ends .....Friday, 26 September
Graduation .....Friday, 26 September
Quarter 2 Begins .....Monday, 29 September
Columbus Day (holiday) .....Monday, 13 October
Veterans Day (holiday) .....Monday, 27 October
Thanksgiving Day (holiday) .....Thursday, 27 November
Examination Week for Quarter 2 .....15-19 December
Final Date for Completion of Thesis for December
Graduation .....Wednesday, 17 December
Quarter 2 Ends .....Friday, 19 December
Graduation .....Friday, 19 December
Christmas (holiday) .....Thursday, 25 December
Registration for IGEP, Administrative Science CurriculaMonday, 29 December

1976

New Years Day (holiday) .....Thursday, 1 January
Quarter 3 Begins .....Monday, 5 January
Washington's Birthday (Holiday) .....Monday, 16 February
Registration for all Curricula except Administrative Science,
Engr Acoustics, Naval Intelligence .....Monday, 22 March
Examination Week for Quarter 3 .....22-26 March
Final Date for Completion of Thesis for March Graduation Wednesday, 24 March
Quarter 3 Ends .....Friday, 26 March
Graduation .....Friday, 26 March
Quarter 4 Begins .....Monday, 29 March
Memorial Day (holiday) .....Monday, 31 May
Examination Week for Quarter 4 .....14-18 June
Final Date for Completion of Thesis for June Graduation Wednesday, 16 June
Quarter 4 Ends (1975-76) .....Friday, 18 June
Graduation .....Friday, 18 June
Registration for IGEP, Administrative Science Curricula .....Monday, 28 June
Fourth of July (holiday) .....Monday, 5 July
Quarter 1 Begins (1976-77) .....Tuesday, 6 July
Labor Day (holiday) .....Monday, 6 September
Registration for all Curricula except Administrative Science,
Ops Sys Tech (ASW) .....Monday, 20 September
Examination Week for Quarter 1 .....20-24 September
Final Date for Completion of Thesis for September
Graduation .....Wednesday, 22 September
Quarter 1 Ends .....Friday, 24 September
Graduation .....Friday, 24 September
Quarter 2 Begins .....Monday, 27 September

DISTINGUISHED ALUMNI

Among those who have completed a naval postgraduate school curriculum who attained flag (USN) or general (USMC) rank on the active list are the following: (The asterisk (*) indicates those on active list as of 1 November 1973).

Admiral Walter F. Boone
Admiral Arleigh A. Burke
Admiral Maurice E. Curts
Admiral Robert L. Dennison
Admiral Donald B. Duncan
Admiral Cato D. Glover, Jr.
Admiral Roscoe F. Good
Admiral Charles D. Griffin
Admiral Byron H. Hanlon
Admiral Ephraim P. Holmes
Admiral Albert G. Noble
Admiral Alfred M. Pride
Admiral James C. Richardson
Admiral Horacio Rivero, Jr.
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.
Admiral John H. Sides
Admiral Felix B. Stump
Admiral Alfred G. Ward
Admiral John M. Will
Vice Admiral Frederick L. Ashworth
Vice Admiral Harold D. Baker
Vice Admiral Wallace M. Beakley
Vice Admiral George F. Beardsley
Vice Admiral Frank E. Beatty
Vice Admiral Fred G. Bennett
Vice Admiral Charles T. Booth, II
Vice Admiral Harold G. Bowen, Jr.
Vice Admiral Carleton F. Bryant
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral Ralph W. Christie
Vice Admiral John B. Colwell
Vice Admiral Thomas F. Connolly
Vice Admiral Glenn B. Davis
Vice Admiral Vincent P. Depoix*
Rear Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho
Vice Admiral Irving T. Duke
Vice Admiral Clarence E. Ekstrom
Vice Admiral Albert J. Fay
Vice Admiral Emmet P. Forrestel
Vice Admiral Laurence H. Frost
Vice Admiral William E. Gentner, Jr.
Vice Admiral Arthur R. Gralla
Vice Admiral Elton W. Grenfell
Vice Admiral Robert W. Hayler
Vice Admiral Truman J. Hedding
Vice Admiral Edwin B. Hooper*
Vice Admiral George F. Hussey, Jr.
Vice Admiral Thomas B. Inglis
Vice Admiral Andrew M. Jackson, Jr.
Vice Admiral Albert E. Jarrell
Lieutenent General Clayton C. Jerome
Vice Admiral Robert T. S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Jerome H. King, Jr.*
Vice Admiral Harold O. Larson
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance
Vice Admiral William J. Marshall
Vice Admiral Charles B. Martell
Vice Admiral Kleber S. Masterson
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson
Vice Admiral Frederick H. Michaelis*
Vice Admiral Marion E. Murphy
Vice Admiral Lloyd M. Mustin
Vice Admiral Frank O'Beirne
Vice Admiral Francis P. Old
Vice Admiral Howard E. Orem
Vice Admiral Harvey E. Overesch
Vice Admiral Edward N. Parker
Vice Admiral Raymond E. Peet*
Vice Admiral Charles A. Pownall
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Hyman G. Rickover*
Vice Admiral Rufus E. Rose
Vice Admiral Richard W. Ruble
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin, Jr.
Vice Admiral Harry Sanders
Vice Admiral Walter G. Schindler
Vice Admiral William A. Schoech
Vice Admiral Harry E. Sears
Vice Admiral Thomas G. W. Settle
Vice Admiral Wallace B. Short
Vice Admiral William R. Smedberg, III
Vice Admiral Chester C. Smith
Vice Admiral John V. Smith
Vice Admiral Roland N. Smoot
Lieutenent General Edward W. Snedeker
Vice Admiral Selden B. Spangler
Vice Admiral Thomas M. Stokes
Vice Admiral John Sylvester
Vice Admiral George C. Towner
Vice Admiral Robert L. Townsend
Vice Admiral Aurelius B. Vosseller
Vice Admiral Thomas J. Walker, III
Vice Admiral Charles E. Weakley
Vice Admiral Charles Wellborn, Jr.
Vice Admiral Ralph Weymouth
Vice Admiral Ralph E. Wilson
Rear Admiral William C. Abhau
Rear Admiral Charles Adair
Rear Admiral Robert E. Adamson, Jr.*
Rear Admiral John W. Ailes, III
Rear Admiral Herbert S. Ainsworth*
Rear Admiral Frank Akers
Rear Admiral Charles C. Anderson
Rear Admiral Herbert H. Anderson
Rear Admiral Roy G. Anderson*
Rear Admiral William L. Anderson
Rear Admiral Burton H. Andrews
Rear Admiral Erasmus W. Armentrout, Jr.
Rear Admiral Henry J. Armstrong
Rear Admiral Parker B. Armstrong*
Major General George C. Axtell, Jr.*
Rear Admiral Watson O. Bailey
Rear Admiral William B. Bailey
Rear Admiral Fred E. Bakutis
Rear Admiral Nathaniel C. Barker
Rear Admiral Richard W. Bates
Rear Admiral Robert L. Baughan, Jr.*
Rear Admiral Fred H. Baughman*
Rear Admiral John K. Beling
Rear Admiral David B. Bell
Rear Admiral Allen A. Bergner
Rear Admiral Philip A. Beshany
Rear Admiral Abel T. Bidwell
Rear Admiral Karl J. Biederman
Major General Arthur F. Binney
Rear Admiral Horace V. Bird
Rear Admiral Worthington S. Bitler
Rear Admiral Earnest Blake
Rear Admiral Calvin M. Bolster
Rear Admiral William A. Bowers
Rear Admiral Selman S. Bowling
Rear Admiral John L. Boyes*
Rear Admiral Frank A. Braisted
Rear Admiral Boynton L. Braun
Rear Admiral Harold M. Briggs
Rear Admiral William A. Brockett
Rear Admiral Robert Brodie, Jr.
Rear Admiral Clarence Broussard
Rear Admiral Bert F. Brown
Rear Admiral Henry C. Bruton
Rear Admiral William C. Bryson
Rear Admiral Charles A. Buchanan
Rear Admiral William H. Buracker
Rear Admiral Raymond W. Burk*
Rear Admiral Sherman E. Burroughs
Rear Admiral Jose M. Cabanillas
Rear Admiral Joseph W. Callahan
Rear Admiral Harold A. Carlisle
Rear Admiral Milton O. Carlson
Rear Admiral Albert S. Carter
Rear Admiral Worrall R. Carter
Rear Admiral Gordon L. Caswell
Rear Admiral Charles J. Cater
Rear Admiral Robert W. Cavenagh
Rear Admiral Leonard C. Chamberlin
Rear Admiral Lester S. Chambers
Rear Admiral Lucius H. Chappell
Rear Admiral John D. Chase*
Rear Admiral Kenan C. Childers, Jr.
Rear Admiral William P. Chilton
Rear Admiral Ernest E. Christensen
Rear Admiral Thomas J. Christman*
Rear Admiral Karl J. Christoph
Rear Admiral Albert H. Clancy, Jr.
Rear Admiral David H. Clark
Rear Admiral Henry G. Clark, CEC
Rear Admiral Jeane R. Clark
Rear Admiral Leonidas D. Coates, Jr.
Rear Admiral Joe B. Cochran
Rear Admiral James E. Cohn
Rear Admiral Philip P. Cole
Rear Admiral William M. Cole
Rear Admiral Warren M. Cone*
Rear Admiral Samuel M. Cooley, Jr.*
Rear Admiral Joshua W. Cooper
Rear Admiral Frank W. Corley, Jr.*
Rear Admiral John T. Corwin
Rear Admiral Stanley T. Counts*
Rear Admiral Roy T. Cowdrey
Rear Admiral Donald V. Cox*
Rear Admiral Richard S. Craighill
Rear Admiral John S. Crenshaw
Rear Admiral Samuel H. Crittenden, Jr.
Rear Admiral Robert E. Cronin

Rear Admiral Gordon J. Crosby
Rear Admiral John E. Dacey
Rear Admiral Anthony L. Danis
Rear Admiral James A. Dare
Rear Admiral Lawrence R. Daspit
Rear Admiral James W. Davis
Rear Admiral John B. Davis, Jr.
Rear Admiral Ranson K. Davis
Rear Admiral Kenneth V. Dawson
Rear Admiral Dwight H. Day
Rear Admiral George H. Debaun
Rear Admiral Tyler F. Dedman*
Rear Admiral Walter Dedrick*
Rear Admiral Ernest W. Dobie, Jr.
Rear Admiral Frank R. Dodge
Rear Admiral Joseph E. Dodson
Rear Admiral Oscar H. Dodson
Rear Admiral Marshall E. Dornin
Rear Admiral Jack S. Dorsey
Rear Admiral Wallace R. Dowd, Jr.*
Rear Admiral Willard M. Downes
Rear Admiral Clayton R. Dudley
Rear Admiral Clifford H. Duerfeldt
Rear Admiral Henry E. Eccles
Rear Admiral Edward H. Eckelmeyer, Jr.
Rear Admiral Donald T. Eller
Rear Admiral Robert B. Ellis
Rear Admiral Gordon S. Everett
Rear Admiral Marvin P. Evenson
Rear Admiral Delmer S. Fahrney
Rear Admiral Edward J. Fahy
Rear Admiral James M. Farrin, Jr.
Rear Admiral Emerson E. Fawkes
Rear Admiral James M. Fernald
Rear Admiral William E. Ferrall
Rear Admiral Clifford A. Fines
Rear Admiral Francis J. Fitzpatrick
Rear Admiral Morton K. Fleming, Jr.
Rear Admiral William B. Fletcher, Jr.
Rear Admiral William O. Floyd
Rear Admiral Eugene B. Fluckey
Rear Admiral Thomas J. Flynn
Rear Admiral Robert J. Foley
Rear Admiral Edward C. Forsyth
Rear Admiral John E. Fradd
Rear Admiral George K. Fraser
Rear Admiral Mason B. Freeman
Rear Admiral Robert B. Fulton, II
Rear Admiral Frederick R. Furth
Rear Admiral Walter D. Gaddis*
Rear Admiral Daniel V. Gallery
Rear Admiral Donald T. Giles
Rear Admiral Fillmore B. Gilkeson*
Rear Admiral John A. Glick
Rear Admiral Robert O. Glover
Rear Admiral William B. Goggins
Rear Admiral Robert B. Goldman
Rear Admiral Alexander S. Goodfellow, Jr.
Rear Admiral Willard K. Goodney
Rear Admiral Roy W. M. Graham
Rear Admiral Etheridge Grant
Rear Admiral Alfred M. Granum
Rear Admiral Orville F. Gregor
Rear Admiral Bradford E. Grow
Rear Admiral James C. Guillot
Rear Admiral Frank S. Haak*
Rear Admiral Frederic S. Habecker
Rear Admiral Wesley M. Hague
Rear Admiral Stanley M. Haight
Rear Admiral Hamilton Hains
Rear Admiral Grover B. H. Hall
Rear Admiral George G. Halvorson*
Rear Admiral Dewitt C. E. Hamberger
Rear Admiral William M. Harnish*
Rear Admiral Harold S. Harnly
Rear Admiral William L. Harris, Jr.*
Rear Admiral Lloyd Harrison
Rear Admiral Clarence M. Hart*
Rear Admiral Robert S. Hatcher
Rear Admiral Valery Havard, Jr.
Rear Admiral Hugh E. Haven
Rear Admiral William R. Headden
Rear Admiral Vincent P. Healey
Rear Admiral George L. Heath
Rear Admiral Paul R. Heineman
Rear Admiral Guy B. Helmick
Rear Admiral William P. Hepburn
Rear Admiral Lee R. Herring
Rear Admiral Edwin W. Herron
Rear Admiral Clarence A. Hill
Rear Admiral Wellington T. Hines
Rear Admiral Charles M. E. Hoffman
Rear Admiral Carleton C. Hoffner
Rear Admiral James H. Hogg
Rear Admiral James B. Hogle
Rear Admiral George A. Holderness, Jr.
Rear Admiral Paul A. Holmberg
Rear Admiral Carl O. Holmquist
Rear Admiral Leroy V. Honsinger
Rear Admiral Edwin B. Hooper*
Rear Admiral Lewis A. Hopkins*
Rear Admiral Charles F. Horne, Jr.
Rear Admiral Martin P. Hottel
Rear Admiral Herbert S. Howard
Rear Admiral Hamilton W. Howe
Rear Admiral Miles H. Hubbard
Rear Admiral Lester J. Hudson
Rear Admiral Harry Hull
Rear Admiral Harry R. Hummer, Jr.
Rear Admiral George P. Hunter
Rear Admiral William D. Irvin
Rear Admiral Joseph A. Jaap
Major General Samuel S. Jack
Rear Admiral David H. Jackson*
Rear Admiral Jack M. James
Rear Admiral Ralph K. James
Rear Admiral Joseph F. Jelley, Jr.
Rear Admiral Frank L. Johnson
Rear Admiral Harry D. Johnston
Rear Admiral Horace B. Jones, CEC
Rear Admiral Allen R. Joyce
Rear Admiral William W. Juvenal
Rear Admiral Benjamin Katz
Rear Admiral Thomas J. Kelly
Rear Admiral John D. Kelsey
Rear Admiral Marvin G. Kennedy
Rear Admiral John S. Kern*
Rear Admiral Thomas S. King, Jr.
Rear Admiral Thomas B. Klakring
Rear Admiral William M. Klee
Rear Admiral Denys W. Knoll
Rear Admiral Theodore H. Kobey
Rear Admiral Edgar P. Kranzfelder
Rear Admiral William E. Kuntz
Rear Admiral Thomas R. Kurtz, Jr.
Rear Admiral David Lambert
Major General Frank H. Lamson-Scribner
Rear Admiral George A. Lange
Rear Admiral Richard A. Larkin
Rear Admiral Robert E. Laub
Rear Admiral Martin J. Lawrence
Rear Admiral Frank C. Layne
Rear Admiral William H. Leahy
Rear Admiral Kent L. Lee*
Rear Admiral Paul F. Lee
Rear Admiral Wilson D. Leggett, Jr.
Rear Admiral William E. Lemos*
Rear Admiral John C. Lester
Rear Admiral Joseph S. Lillard
Rear Admiral Isham W. Linder*
Rear Admiral Orlin L. Livdahl
Rear Admiral William H. Livingston*
Rear Admiral Theodore C. Lonnquest
Rear Admiral Almon E. Loomis
Rear Admiral Wayne R. Loud
Rear Admiral Charles H. Lyman, III
Rear Admiral Duncan C. Macmillan
Rear Admiral Charles J. Maguire
Rear Admiral Joseph B. Maher
Rear Admiral Harry C. Mason
Rear Admiral Bob O. Mathews
Rear Admiral William S. Maxwell
Rear Admiral Brian McCauley*
Rear Admiral Thomas R. McClellan
Rear Admiral Melvyn H. McCoy
Rear Admiral Francis C. B. McCune
Rear General Keith B. McCutcheon
Rear Admiral Eugene F. McDaniel
Rear Admiral William T. McGarry
Rear Admiral John B. McGovern
Rear Admiral Donald McGregor
Rear Admiral Harry H. McIlhenny
Rear Admiral Logan McKee
Rear Admiral William R. McKinney
Rear Admiral John B. McLean
Rear Admiral Philip S. McManus
Rear Admiral James A. McNally
Rear Admiral Robert W. McNitt
Rear Admiral Francis J. Mee
Rear Admiral John L. Melgaard
Rear Admiral Robert E. Melling
Rear Admiral Wm. K. Mendenhall, Jr.
Rear Admiral Jeffrey C. Metzel, Jr.*
Rear Admiral Roderick O. Middleton
Rear Admiral George H. Miller
Rear Admiral Rupert S. Miller*
Rear Admiral Robert G. Mills*
Rear Admiral Clinton A. Misson
Rear Admiral Chauncey Moore
Rear Admiral Michael U. Moore
Rear Admiral Robert L. Moore, Jr.
Rear Admiral Henry G. Moran
Rear Admiral Armand M. Morgan
Rear Admiral Robert W. Morse
Rear Admiral Thomas H. Morton
Rear Admiral William E. Mullan
Rear Admiral Allen P. Mullinnix
Rear Admiral Albert C. Murdaugh
Rear Admiral Charles D. Murphey
Rear Admiral John W. Murphy, Jr.
rear Admiral Richard E. Myers
Rear Admiral Cliver F. Naquin
Rear Admiral Frederick J. Nelson
Rear Admiral Charles A. Nicholson, II
Rear Admiral William R. D. Nickelson, Jr.
Rear Admiral Philip Niekum, Jr.
Rear Admiral Hugh R. Nieman, Jr.
Rear Admiral Emmet O'Beirne
Rear Admiral Timothy J. O'Brien
Rear Admiral Edward J. O'Donnell

Rear Admiral Eliot Olsen
Rear Admiral William H. Organ
Rear Admiral James B. Osborn
Rear Admiral William W. Outerbridge
Rear Admiral Thomas B. Owen
Rear Admiral James R. Pahl
Rear Admiral Roger W. Paine
Rear Admiral Edward E. Pare
Rear Admiral Charles W. Parker
Rear Admiral Goldsborough S. Patrick
Rear Admiral John B. Pearson, Jr.
Rear Admiral John H. Pedersen
Rear Admiral Henry S. Persons
Rear Admiral Forrest S. Petersen*
Rear Admiral Carl J. Pfingstag
Rear Admiral Neill Phillips
Rear Admiral Richard H. Phillips
Rear Admiral Ben B. Pickett
Rear Admiral Paul E. Pihl
Rear Admiral Frank L. Pinney, Jr.
Rear Admiral Donald T. Poe*
Rear Admiral Karl F. Poehlmann
Rear Admiral Frank H. Price*
Rear Admiral Walter H. Price
Rear Admiral William M. Pugh, II*
Rear Admiral Schuyler N. Pyne
Rear Admiral Alston Ramsay
Rear Admiral William T. Rassieur
Rear Admiral Charles F. Rauch, Jr.*
Rear Admiral Ralph W. Rawson
Rear Admiral Harry L. Reiter, Jr.
Rear Admiral James R. Z. Reynolds
Rear Admiral Joseph E. Rice
Rear Admiral Alvin F. Richardson
Rear Admiral Robert E. Riera*
Rear Admiral Basil N. Rittenhouse, Jr.
Rear Admiral James M. Robinson
Rear Admiral Walter F. Rodee
Rear Admiral William K. Romoser
Rear Admiral John B. Rooney
Rear Admiral Gordon Rowe
Rear Admiral Donald Royce
Rear Admiral Edward A. Ruckner
Rear Admiral Thomas J. Rudden, Jr.
Rear Admiral Merrill H. Sappington*
Rear Admiral Ben W. Sarver
Rear Admiral Edwin S. Schanze
Rear Admiral Raymond J. Schneider*
Rear Admiral Malcolm F. Schoeffel
Rear Admiral Albert B. Scoles
Rear Admiral John A. Scott*
Rear Admiral Roger F. Scott
Rear Admiral Leslie H. Sell*
Rear Admiral John N. Shaffer
Rear Admiral Louis D. Sharp, Jr.
Rear Admiral Andrew G. Shepard
Rear Admiral Tazewell T. Shepard, Jr.*
Rear Admiral William B. Sieglaff
Rear Admiral William Sihler
Rear Admiral George A. Sinclair
Rear Admiral Harry Smith
Rear Admiral James H. Smith, Jr.
Rear Admiral Levering Smith*
Rear Admiral Robert H. Smith
Rear Admiral Russell S. Smith
Rear Admiral Stirling P. Smith
Rear Admiral William R. Smith, III
Rear Admiral John A. Snackenberg
Rear Admiral Joseph E. Snyder, Jr.*
Rear Admiral Robert H. Speck
Rear Adiral Roger E. Spreen*
Rear Admiral George B. H. Stallings
Rear Admiral Frederick C. Stelter, Jr.
Rear Admiral Edward I. Stephan
Rear Admiral Earl E. Stone
Rear Admiral Hubert E. Strange
Rear Admiral Charles W. Styer
Rear Aemiral Robert L. Swart
Rear Admiral John D. Sweeney
Rear Admiral William E. Sweeney
Rear Admiral James B. Sykes
Rear Admiral Frank R. Talbot
Rear Admiral Arthur H. Taylor
Rear admiral Edwin A. Taylor
Rear Admiral Edwin J. Taylor, Jr.
Rear Admiral John McN Taylor
Rear Admiral Edward M. Thompson
Rear Admiral John M. Tierney*
Rear Admiral Rutledge B. Tompkins
Rear Admiral Theodore A. Torgerson
Rear Admiral Arnold E. True
Rear Admiral Samuel M. Tucker
Rear Admiral David M. Tyree
Rear Admiral Archibald E. Uehlinger
Rear Admiral Frank Virden
Rear Admiral Ernest S. Vonkleeck, Jr.
Rear Admiral John R. Wadleigh
Rear Admiral Delos E. Wait
Rear Admiral George H. Wales
Rear Admiral Edward K. Walker
Rear Admiral Kenneth C. Wallace*
Rear Admiral Edward C. Waller, III*
Rear Admiral Audley L. Warburton
Rear Admiral Frederick B. Warder
Rear Admiral John R. Waterman
Rear Admiral Odale D. Waters, Jr.
Rear Admiral James D. Watkins*
Rear Admiral David A. Webster*
Rear Admiral John F. Wegforth
Rear Admiral Daniel K. Weitzenfeld
Rear Admiral Oscar A. Weller
Rear Admiral Albert A. Wellings
Rear Admiral Robert H. Wertheim*
Rear Admiral Thomas R. Weschler*
Rear Admiral Charles D. Wheelock
Rear Admiral Walter J. Whipple
Rear Admiral David C. White
Rear Admiral William J. Whiteside
Rear Admiral Edwin R. Wilkinson
Rear Admiral Delbert F. Williamson
Rear Admiral Emile R. Winterhaler
Rear Admiral Frederick S. Withington
Rear Admiral Narvin O. Wittman*
Rear Admiral Robert W. Wood
Rear Admiral Mark W. Woods*
Rear Admiral Edward L. Woodyard
Rear Admiral Earl P. Yates*
Rear Admiral Elmer E. Yeomans
Rear Admiral Rupert M. Zimmerli

Selectees

Rear Admiral John H. Alvis*
Rear Admiral Lucien Capone, Jr.*
Rear Admiral Edward W. Carter, III*
Rear Admiral Murray C. Cook*
Rear Admiral John T. Coughlin*
Rear Admiral Claude P. Ekas, Jr.*
Rear Admiral Lee W. Fisher*
Rear Admiral James H. Foxgrover*
Rear Admiral Robert K. Geiger*
Rear Admiral Norman K. Green*
Rear Admiral Kenneth G. Haynes*
Rear Admiral M. Staser Holcomb*
Rear Admiral James E. McKenna*
Rear Admiral Gordon R. Nagler*
Rear Admiral Roy D. Snyder*
Rear Admiral Ernest E. Tissot, Jr.*

HISTORY

The Naval Postgraduate School is in its 65th year of providing advanced education for commissioned officers of the United States Navy. When it was established at Annapolis on 9 June 1909, only ten officers made up the class, three professors formed the faculty, and marine engineering was the only curriculum. It was called the Postgraduate Department of the U. S. Naval Academy.

The school suspended operations during World War I. When classes resumed in 1919, mechanical and electrical engineering were added to the course of instruction. Later, ordnance engineering, radio engineering, aerological engineering and aeronautical engineering were introduced as the Navy continued to recognize its need for officers with technical knowledge. The postgraduate department was renamed the United States Naval Postgraduate School, but still operated as a part of the Naval Academy.

In 1927 the General Line Curriculum was established to provide instruction which would acquaint junior line officers with modern developments within the Navy, and to broaden their professional knowledge for future command at sea. It remained an integral part of the school until World War II, when the general line students returned to the fleet. Enrollment in the other curricula continued to increase during the war years as the school grew to meet the needs of the Navy. After the 1945 armistice, the Navy began plans to move the Postgraduate School away from Annapolis and to improve its professional status. The post-war period also saw the General Line School re-established, this time at Newport, Rhode Island, and at Monterey, California. Between 1945 and 1948, Congress established the school as a separate activity under its own superintendent, created the office of academic dean, granted the superintendent authority to award the bachelor's, master's and doctor's degrees, and approved Monterey as the future home of the school.

After purchasing the former Del Monte Hotel and surrounding acreage, the Naval Postgraduate School was officially established on the West Coast on 22 December 1951. Five years later the Navy Management School joined the General Line School as a component of the Postgraduate School, and for the first time a Bachelor of Science curriculum was offered to selected officers who had not completed their undergraduate education. A further need for baccalaureate courses resulted in the inauguration of the Bachelor of Arts curriculum in 1961.

A year later the Chief of Naval Personnel authorized a major internal reorganization of the school. The management, engineering and general line schools merged, in effect making the Naval Postgraduate School a naval university, unified in policy, procedure and purpose.

The last major revision took place in January 1967 after considerable evaluation of curricula. Operations were shifted from a five term to a four-quarter academic calendar.

Since 1946 the School has awarded 5667 bachelor's degrees, 6037 master's degrees, 165 engineer's degrees, and 55 doctoral degrees. At the present time the major emphasis is on the graduate degrees.

As we move toward the mid 1970s, the Chairman of the Joint Chiefs of Staff, Admiral T. H. Moorer, has made the following statement about postgraduate education:

"The importance of postgraduate education continues to grow in the 1970s as we progress into an even more demanding technological and management environment. This development of the Navy officer corps, through advanced education and training under the guidance of very outstanding civilians and of military professionals, is an essential part of our preparedness for future challenges and opportunities which await our country at sea. The high caliber of officers selected for postgraduate training highlights the importance which the Navy attaches to the quality of personnel."

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are a Provost/Academic Dean who is the senior member of the civilian faculty; and three captains of the line—a Chief of Staff, a Director of Programs, and a Director of Military Operations and Logistics.

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices

and Academic Departments. The former are staffed by naval officers and civilian faculty members whose primary functions are three-fold: (1) academic counseling and military supervision of officer students; (2) curriculum development and management to insure attainment of professional and academic objectives; and (3) liaison with curricular sponsor representatives. Officer students in each curricula group pursue similar or closely related curricula.

Within each of these areas a common core program of study is followed for at least half the period of residency. Officer students are grouped into the following curricular programs areas:

Aeronautical Engineering
Electronics and Communications Engineering
Weapons Engineering
Naval Engineering
Environmental Sciences
Administrative Science & Computer Science
Operations Research/Systems Analysis
Engineering Science
Naval Intelligence

Objectives and details of curricula are described in another section of this catalogue.

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into nine academic departments and two interdisciplinary groups:

Aeronautics
Computer Science Group
Electrical Engineering
Government
Mathematics
Mechanical Engineering
Meteorology
Oceanography
Operational Systems Technology Group
Operations Research and Administrative Sciences
Physics and Chemisty

Over five-sixths of the teaching staff are civilians of varying professional rank and the remainder naval officers.

Detailed listings of faculty members and course offerings are contained in later sections of the catalogue.

The Academic Program organization described is supervised by the Director of Programs and a civilian Dean of Programs who collaborate to share jointly the responsibilities for planning, conduct and administration of the several educational programs.

The close tie between elements of this dual organization is further typified by the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula—the Navy's needs being the responsibility of the Curricular Officer, and academic soundness being the responsibility of the Academic Associate.

The educational programs conducted at Monterey include scientific, engineering, and administrative science curricula. Supplementing these is the engineering science program. The major portion of the officers selected for this program undergo two terms of refresher and prerequisite study. Those who are so motivated may be selected by the Superintendent for a two or three year engineering or science curriculum. Those not selected continue in a non-degree program with the primary objective of basic scientific education which will better prepare them for advanced functional training and/or general updating in technical areas.

Logistic service support is rendered by conventional departments such as Supply and Disbursing, Public Works, Dental, Medical, etc., grouped organizationally under a Director for Military Operations and Logistics. Certain other officers such as the Comptroller and Public Affairs Officer are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fishermen's Wharf. The site of the School is the former luxury Del Monte Hotel of pre-World War II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research and a nearby laboratory and recreation area. The total campus covers approximately 600 acres.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its old Spanish architecture.

Most of the academic classrooms, laboratories, and offices are located in Spanagel, Bullard, Halligan, Root and Ingersoll Halls. The newest building is the 400,000 volume Dudley Knox Library which was completed early in 1972. Adjacent to the main academic buildings is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

THE MONTEREY PENINSULA

For any military member coming to the Naval Postgraduate School, whether as student, staff or faculty, the Monterey Peninsula offers a kaleidoscope of activities and opportunities absolutely distinctive in nature. The Naval Postgraduate School grounds and facilities fit like a piece from a crossword puzzle into the scheme of Monterey and its environs. Its Spanish style structures, stately trees and ornamental flowers and shrubbery repeat the theme of communities that line the Pacific Ocean on California's Central Coast.

Nearby are the quaint streets and shops of Carmel-by-the-Sea; the flower-covered yards and beaches of Pacific Grove, the Monarch Butterfly Capital of the World; the breathtaking beauty of Carmel Valley and its uniquely California topography; and the imposing sand dunes that mark the location of the Army's spacious Fort Ord at Seaside.

If you are a golf or camera aficionado, you will revel in the imposing 17-Mile Drive, its beautiful homes, irresistible golf courses, and unusual seascapes. Spyglass Hill, Pebble Beach, and Cypress Point Golf Courses are just a few of those to be found here and elsewhere on the Peninsula. And, on the 17-Mile Drive, you are likely to meet up with one of the famous movie or entertainment personalities who own homes here ... or some of the almost-tame deer and other wildlife that live in abundance and safety with their human neighbors.

Just a little further down the beach is Pt. Lobos, once a leading west coast whaling station, with its roller coaster hills, sheer craggy cliffs, and sea tunnels carved by thousands of years of spectacular wave action. And only a short half-hour's drive from there, down the winding and breathtaking Highway 1, is Big Sur country ... known for its cattle ranches, beautiful big trees and excellent camping facilities ... all within a moment's drive of giant seawalls created by nature and the restlessness of the Pacific Ocean.

If you are inclined to move northward from Monterey, there is Roaring Camp just east of Santa Cruz, once one of the early California gold rush camps made famous in story and song. There you can enjoy the giant redwoods of California while riding an old steam engine ... and see where men and women sought, won and lost fortunes in hours. Some of the graceful old trees there measure more than 15 feet in diameter. Santa Cruz county is also the location of mile after mile of state beaches and parks.

The Monterey Peninsula, known for its beauty for a century, is now famous for its many cultural and sports events. The Carmel Bach Festival in August lasts for two weeks and the Monterey Jazz Festival attracts most of the greats from the jazz world for a weekend in October. In addition to the Monterey Symphony Orchestra, the community supports several other concert series as well as individual performances. The lights come up every weekend on two to four live theatre stages; the First Theatre in Monterey has been presenting shows for the past 120 years or so. The Bing Crosby Pro-Am Golf Tournament in January is the best known of several golfing events held every year. The Laguna Seca Raceway is the scene of sports car racing events held twice yearly, attracting crowds up to 40,000 in size.

In addition to its cultural and sports activities, the Monterey Peninsula is the home of a number of college level educational institutions. Although the Postgraduate School is the most prestigious, the Defense Language Institute whose innovative methods of language instruction have been copied around the world is also a leader in its field. It is open only to military personnel. The largest civilian school is the Monterey Peninsula College which offers the Associate Degree to its student body of over 6,000 in both day and evening classes. The Monterey Institute of Foreign Studies offers courses for the baccalaureate and master's degree. This school concentrates on studies in language, history, world area study and education. Golden Gate University operates a branch campus with courses leading to the master's degree in business adminstration.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the officers of the Postgraduate School.

LaMesa Village, located 3 miles from the School, consists of former Wherry Housing, Capehart Housing and Townhouses. There are a total of 877 units of public quarters for officer students. An elementary school is located within the housing area. Limited housing for single students is available in the BOQ located on the main campus in Herrmann Hall.

Student services include a campus branch of Bank of America, Navy-Federal Credit Union, U. S. Post Office, Student Mail Center, Navy Exchange and a child care center. A large commissary is located at Fort Ord and is available to Navy personnel.

Medical facilities include a Dispensary, supported by the U. S. Army Hospital at Fort Ord (7 miles away), and the U. S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

The center of campus social activity is the Commissioned Officers and Faculty Club, located in the old hotel building. There are many beautifully appointed rooms, just as they were at the turn of the century, including a ballroom and Open Mess. Two beautiful chapels are located on the main campus.

Student wives and wives of allied officers are active in the Officer Student Wives Club, the International Wives Club, as well as a Little Theater group which puts on three productions a year.

Recreational facilities include a swimming pool, an 18-hole golf course, putting green, tennis courts, ping pong and badminton courts, basketball and volley ball courts, a softball diamond, picnic grounds, bowling lanes, driving range, archery range, and gymnasium. Included in the many activities which participate in competition off campus are Ladies Golf Association, Mens Golf Association, Soccer Club, Rugby Club, Lacross Club, Ski Club, Karate Club, Tennis Club, and basketball and softball teams. The School also has a very active Military Amateur Radio Station and a Navy Flying Club.

Personnel assigned to the Postgraduate School have a very active Sailing Association open to sponsors and their dependents as well as members of the

faculty. Sailing conditions are among the finest on the West Coast with excellent weather prevailing from February through November. The School's recreation department schedules the 3 Shields Class Racing Sloops, 2 Santana-22s and 1 Columbia 22 on a first-come first-served basis. Classes for beginners and advanced sailing enthusiasts are conducted twice a year, following the January and July inputs. The School works closely with civilian yacht clubs to coordinate many sailing events throughout the year and, in addition, hosts the annual Navy West Coast Match racing championships.

TEXTBOOKS

The Naval Postgraduate School operates a bookstore under the Navy Exchange System. It stocks all required textbooks and related school supplies. Students are required to purchase their books either from the school or local bookstores, or from other students.

Prospective students desiring a copy of the Postgraduate School Catalogue may request one by sending a check for $ 1.25 to: Navy Exchange Bookstore, Naval Postgraduate School, Monterey, California 93940.

ADMISSIONS PROCEDURES

U. S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to OPNAV Notice 1520, Subject: Postgraduate Educational Programs, which is published annually by the Chief of Naval Operations. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Chief of Naval Personnel to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by a BUPERS Notice at the earliest feasible date after the meeting of the selection board, or by official correspondence.

The curriculum numbers as assigned in the annual OPNAV Notice 1520 are repeated in the title of each curriculum and are also included in the list of curricula at the Postgraduate School on page 28 and the list of curricula conducted at civilian institutions on page 56.

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U. S. Marine Corps, or the Commandant U. S. Coast Guard, as appropriate.

Military officers from Allied Countries may be admitted to certain curricula at the Postgraduate School. Such admission is subject to availability of quotas assigned to each country. Applications must be made through normal channels of communication and not sent directly to the Naval Postgraduate School. The academic standards described in this Catalogue for admission to each curricula must be met.

Anyone having questions regarding admission procedures may write to the Dean of Admissions, Naval Postgraduate School, Monterey, California 93940; or telephone 408-646-2391 or AUTOVON 479-2391.

Civilian students are not eligible to attend the Postgraduate School.

TRANSFER OF CREDITS

Upon entry to the Naval Postgraduate School, each student's prior academic record will be evaluated for possible transfer of credit. A course given here may be validated when a course covering the same material has been taken previously; no credit is awarded here in this case, but the student is exempt from taking the course. All graduate level courses taken after completion of the baccalaureate degree may be accepted for credit; graduate level courses certified to be in excess of requirements for the baccalaureate degree and taken in the last term before award of the baccalaureate may be accepted for graduate credit under certain circumstances. Students are encouraged to seek validation or credit for courses by taking a departmental examination. This allows the student to utilize knowledge gained through self-study, experience, or service related courses.

As a consequence of its policy on transfer of credit, the School does not have any fixed residency requirement for the master's degree. Questions on transfer credit may be directed to the Dean of Admissions by letter or AUTOVON 479-2391.

REFRESHER COURSE

After notification of selection, officers are encouraged to write to the Superintendent, Naval Postgraduate School, Monterey, California 93940, Code 0212, for a self-study mathematics (calculus) refresher course. This course, designed for completion in about 150 hours, will be of great assistance in improving mathematics background and restoring study habits. Officers are urged to undertake this program.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. This authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such

degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School was accredited in 1962 as a full member of the Western Association of Schools and Colleges. Initial accreditation as an associate member was given in 1955. Specific engineering curricula have been accredited by the Engineers' Council for Professional Development (ECPD) since 1949.

The Postgraduate School operates under a quarter system, with each term of instruction lasting 12 weeks. The last week of each quarter is set aside for examinations. In addition, there are two 2-week recesses during the academic year, one over Christmas and one during June-July.

Students' performance is evaluated on the basis of a quality point number assigned to the letter grade achieved in a course as follows:

Performance	*Grade*	*Point Value*
Excellent	A	4
	A−	3.7
	B+	3.3
	B	3
	B−	2.7
	C+	2.3
	C	2
	C−	1.7
	D+	1.3
	D	1
Failing	X	0
Incomplete	I	—
Withdrew Passing	W	—
Withdrew Failing	WX	0
Nongraded	N	—
Pass	P	—
Fail	F	—

Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. Hours earned by the grade of P shall be counted toward fulfilling course hours specified by the degree requirements.

A grade of Incomplete (I), if not removed within twelve weeks following the end of the term for which it was received, will be replaced by the grade "X". Exceptions must be individually approved by the Academic Council.

When the quarter hours value of a course is multiplied by the quality point number of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the quarter hour value of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours. Satisfactory academic proficiency at the Naval Postgraduate School has been established at a QPR of 2.0 for all courses of a curriculum.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for this purpose between classes.

The courses listed in this Catalogue are assigned a level of academic credit by the numbers assigned.

0001-0999 No credit
1000-1999 Lower division credit
2000-2999 Upper division credit
3000-3999 Upper division or graduate credit
4000-4999 Graduate credit

The two numbers in parenthesis (separated by hyphens) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned a credit value of 4 quarter hours.

ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include Eta Kappa Nu, Sigma Xi, Tau Beta Pi, as well as ACM (Association for Computing Machinery), AIAA (American Institute of Aeronautics and Astronautics), AMS (American Meteorological Society), ASME (American Society of Mechanical Engineers), ASNE (American Society of Naval Engineers), IEEE (Institute of Electrical and Electronics Engineers, Inc.), ORSA (Operations Research Society of America), and the Marine Technology Society.

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 3.65, or higher, while carrying a minimum academic load of 12 quarter hours.

GRADUATION WITH HONORS. The award of the Master of Science degree may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and is in the upper 10% of the graduating class. The award of a Bachelor's degree may be made "Cum Laude" when a student completes the degree requirements with a minimum of 60-quarter hours in residence and is in the upper 5% of the graduating class.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma Xi, an honorary society founded to recognize excellence in the scientific and engineering disciplines. Students

who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J. C. WOELFEL AWARD. This award is given annually to the United States Naval officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

W. RANDOLPH CHURCH AWARD. This award is given annually to a student on the basis of his performance in mathematics courses. The criteria for selection will include evidence of initiative, scholarly attitude and mathematical maturity. The student need not be a mathematics major, nor must he be a graduate at the time of presentation.

NAVAL ELECTRONICS SYSTEMS COMMAND AWARD IN ELECTRONICS ENGINEERING. This award will be given semiannually to a Master of Science candidate in the Advanced Electronics Engineering Program who has a most outstanding academic record and whose qualities indicate an outstanding military officer.

NAVY LEAGUE OF MONTEREY AWARD FOR ACADEMIC ACHIEVEMENT. This award is presented quarterly to the graduating Navy, Marine Corps, or Coast Guard student (less Ph.D. candidates) who has demonstrated outstanding academic achievement during his enrollment at NPS. The award is made primarily on the basis of the student's academic improvement.

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION AWARDS. Up to three of these awards may be presented each quarter to graduates of the Communications and Engineering Electronics curricula who have demonstrated the highest scholastic achievement.

NAVAL SHIP SYSTEMS COMMAND AWARD IN NAVAL ENGINEERING. This award affords recognition to a graduate of any curriculum leading to a Master of Science degree in Mechanical or Electrical Engineering who has demonstrated academic excellence through attainment of a high Quality Point Rating in addition to an outstanding thesis, and who has exhibited leadership potential in the engineering area.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN OPERATIONS RESEARCH. This award is presented semiannually to an outstanding United States Navy or Marine Corps graduate of the Operations Research/Systems Analysis curriculum. The award is made on the basis of academic record, performance during the student's experience tour, and faculty recommendations.

ADMIRAL WILLIAM ADGER MOFFETT AWARD. This award is presented annually to an outstanding graduate of the Aeronautical Engineering curriculum. The award is made on the basis of the student's academic excellence, including thesis, and his career potential.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS AWARD. This award is presented semiannually to the graduate in an advanced communications degree program achieving an outstanding academic record and exhibiting those qualities indicative of an outstanding military officer.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS CERTIFICATE. This certificate is presented quarterly to the Master of Science graduate who shows the greatest academic improvement in a communications curriculum.

CERTIFICATES OF COMPLETION

Certificates of completion are issued to students who complete programs but do not qualify for a degree. To establish eligibility for a Certificate of Completion, a student must normally maintain an overall QPR of 2.0 or better.

REQUIREMENTS FOR THE BACCALAUREATE DEGREE

1. The Bachelor of Science or the Bachelor of Arts Degree may be awarded for successful completion of a curriculum which has been approved by the Academic Council as meriting the degree. Such curricula shall conform to current practice in other accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Baccalaureate Degree are as follows:

a. 180 quarter hours of which at least 72 hours must be at the upper division level from course numbered at or above 2000.

b. One academic year in residence.

c. 36 quarter hours in the Humanities and the Social Sciences.

d. 36 quarter hours in Mathematics and the Physical Sciences.

e. Completion of the departmental requirements for a well-defined major.

f. A quality point rating of at least 2.00 in all courses taken at the Postgraduate School as well as in the courses in the major.

REQUIREMENTS FOR THE MASTER OF ARTS AND MASTER OF SCIENCE DEGREES

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:

a. 32 quarter hours of graduate level credits of which at least 12 quarter hours must be earned on campus.

b. A thesis or its equivalent is required. If the thesis be waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.

c. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master's degree requires:

a. A baccalaureate degree or the equivalent.

b. Appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.

c. A demonstrated academic potential for completing the curriculum.

4. In order to qualify for a Master's degree, a student first must be admitted to candidacy for the degree. Application for such admission to candidacy shall be made to the Dean of Curricula via the Chairman of the department of the major subsequent to completion of 50% of a curriculum and prior to completion of 75% of the curriculum.

a. Students having a Total QPR of 3.00 or greater at the time of application automatically will be admitted to candidacy.

b. Students having a Total QPR from 2.50 to 2.99, inclusive, will require approval by the Academic Council upon recommendation of the Chairman of the department of the major for admission to candidacy.

c. Students having a Total QPR below 2.50 will not be admitted to candidacy for a Master's degree.

5. To be eligible for the Master's degree, the student must attain a minimum average quality point rating of 3.00 in all of the 4000 and 3000 level courses in his curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DEGREE: ENGINEER

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.

b. An acceptable thesis.

c. One academic year in residence.

d. Departmental requirements for the degree in a specified Engineering field.

e. A quality point rating of at least 3.00 in all graduate courses in the curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DOCTOR'S DEGREE

1. The degree Doctor of Philosophy is awarded as a result of very meritorious and scholarly achievements in a particular field of study which has been approved by the Academic Council as within the purview of the Naval Postgraduate School. A candidate must exhibit faithful and scholarly application to all prescribed courses of study, achieve a high level of scientific advancement, and establish his ability for original investigation.

2. Any program leading to the degree Doctor of Philosophy shall require the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the Naval Postgraduate School.

3. A student seeking to become a candidate for the Doctorate shall hold a Bachelor's degree based on a curriculum that included the prerequisites for full graduate status in the department of his major study, or he shall have pursued successfully an equivalent course of study. The student shall submit his previous record to the Chairman of the Department of his proposed major subject for determination of his acceptability as a Doctoral student. The method of screening applicants shall be the responsiblity of the department, but it will usually involve a written or oral screening examination. No applicant shall take such an examination more than twice.

4. The Doctoral Committee will be nominated by the Department Chairman and approved by the Academic Council. The Committee will consist of five or more members from at least three departments. One member of this Committee may be from another university or appropriate institution. Each member will have earned the doctorate; this re-

quirement may be waived for not more than one of the committee members, if the Academic Dean certifies that selection of the proposed member is in the best interests of the School. At the time that the above Committee is submitted for approval, or at a subsequent time no later than when the student is advanced to candidacy for the doctorate, the major Department Chairman shall designate, for the approval of the Academic Council, the member of the Doctoral Committee who shall serve as Dissertation Supervisor. The Doctoral Committee has responsibility for the program of study, which shall include one or more minor fields, suitable to the needs of the student and the requirements for award of the Doctorate.

5. After his program of study in the major and minor fields has been essentially completed, the student shall be given by his Doctoral Committee a comprehensive Qualifying Examination which shall include both written and oral parts. The oral examination will be administered by the entire Doctoral Committee. The Academic Council will be invited. Passage of the Qualifying Examination will require a unanimous vote of the Doctoral Committee. No student may take the Qualifying Examination more than twice. The result of the examination, whether pass or fail, shall be reported to the cognizant Curricular Officer and to the Academic Council. Each member of the Doctoral Committee shall sign the report.

6. The language requirement is to be satisfied by the student who will demonstrate, before an examiner appointed by the Academic Dean, a satisfactory ability to read work related to his special field of study in at least one language in addition to English. The normally accepted languages are French, German or Russian. However, if the student can demonstrate that enough current technical literature in his major field exists in another language, the Doctoral Committee may approve this language. The required proficiency in the language should be gained early, both to avoid disruption of the research at a critical time, and also to insure that the necessary practice can be combined with learning the literature in the field of specialization. The program of study shall include one or more minor fields, as specified by the Doctoral Committee, suitable to the needs of the student and to the research problem he will undertake. The minor requirement will be satisfied by procedures specified by the department of the minor; these may include written or oral examination, completion of sequence of courses, etc. Upon successful completion of the language requirement and the comprehensive examinations, the student becomes eligible for advancement to candidacy.

7. The distinct requirement of the Doctorate is the successful completion of a scholarly investigation leading to an original and significant contribution to knowledge in the candidate's major area of study. The subject of the investigation must be approved by the Doctoral Committee, who will report the approved subject to the Academic Council. This report must be made no later than the time of request for advancement to candidacy. In any event, the candidate must devote at least six months to research, following the date of advancement to candidacy, before he may expect to present himself for the final examination.

8. When the dissertation research has been completed and a draft has been prepared to the satisfaction of the Dissertation Supervisor, a copy shall be submitted to each member of the Doctoral Committee for approval. Approval by the committee members shall signify the Committee's acceptance of the draft as a basis for the final defense-of-dissertation examination. After obtaining unanimous acceptance of the draft from the Doctoral Committee, the Chairman shall schedule an oral final examination. This examination should not be scheduled earlier than one week following the submission of the draft of the dissertation to the Doctoral Committee. The Academic Council shall be invited. In the final examination, the candidate will present and defend his dissertation and he shall be subject to such questions as the Doctoral Committee and the Academic Council may deem appropriate. Passage of the examination requires a unanimous vote of the Doctoral Committee. The results of the final examination (whether pass or fail) shall be reported to the Academic Council, the report bearing the signatures of all the members of the Committee. If the candidate is passed, this report shall also include:

a. Certification of acceptance of the dissertation.
b. Nomination of the successful candidate for the award of the degree, Doctor of Philosophy.

9. After receiving the report of the Doctoral Committee, the Academic Council will make the final decision whether or not to recommend the candidate to the Superintendent of the Naval Postgraduate School for the award of the Doctor of Philosophy degree.

COOPERATIVE DOCTORAL PROGRAM

The Cooperative Doctoral Program provides civilian scientists and engineers of the Defense Department the opportunity to extend their education to the doctoral level. Candidates for the program must be civilian employees who have already attained the Master's degree, or its equivalent. Acceptance into the program will be based on evaluation of the candidate's academic record and professional experience by the Postgraduate School. The evaluation will usually include administering the same screening examination given to resident officer students.

Successful candidates will be appointed to the Faculty of the Postgraduate School with the rank of

Visiting Instructor. The home organization of the candidate is expected to provide his billet under a non-reimbursable billet arrangement. The Visiting Instructor will spend six to eight hours per week on faculty duties and the balance on his graduate studies. An adequately qualified candidate should be able to complete his doctorate in about two and a half years of residence.

Doctoral programs are available in the following disciplines: aeronautics, electrical engineering, mechanical engineering, meteorology, oceanography, operations research, and physics. Interested candidates are invited to address letters of inquiry to the Academic Dean, Naval Postgraduate School, Monterey, California 93940.

NAVAL POSTGRADUATE SCHOOL FOUNDATION

The Foundation is a non-profit corporation whose purposes are:

> "to solicit, receive, and administer contributions and make donations and dispense charitable contributions ... and otherwise aid, encourage and support the traditions of the Naval Postgraduate School ..."

The corporation was formed in December 1970, and has since served as a vehicle by which large and small tax-exempt gifts have been easily and quickly given to the School. These gifts are all applied to those needs or purposes which would otherwise—in these days of severe fiscal restraint—be poorly- or not-at-all funded.

The Rear Admiral John Jay Schieffelin Award for Excellence in Teaching was endowed through the Foundation. A black granite sculpture, FLIGHT, located in the Dudley Knox Library, was donated to help publicly honor the recipients of this prestigious and valuable award.

Dependents graduating from high school while their sponsor is attached to the Naval Postgraduate School are eligible for scholarships offered by the Naval Postgraduate School Foundation. These scholarships are based entirely on merit, and are usually awarded in the amount of $500 per recipient.

The School's Sailing Association owes the majority of its present assets to donations made to the Foundation. Small donations have also been received from some "friends of the Library" who wished to create a small but meaningful and useful memorial.

The Directors of the corporation are civilians, except for the Superintendent who serves to assure that only gifts appropriate to the School are accepted.

Individuals wishing to participate in the work of the Foundation may write to the Secretary, Naval Postgraduate School Foundation, Inc., Naval Postgraduate School, Monterey, California 93940.

SUPERINTENDENT'S GUEST LECTURE PROGRAM

Throughout the Academic Year lectures will be presented on Tuesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international, government, sociological, and military affairs. Occasionally speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

HUMAN GOALS

In accordance with CNO directives which promulgated the Navy Human Goals Plan and designated the Naval Postgraduate School as a key career development point, the objectives of the Plan are being formally integrated into each of the curricula by the inclusion of an appropriate academic course therein. All students will be required to participate and will be scheduled for optimum effectiveness.

W. R. CHURCH COMPUTER CENTER

STAFF

DOUGLAS GEORGE WILLIAMS, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

ROGER RENE HILLEARY, Manager, User Services (1962); B.A., Pomona College, 1953; M.S., Naval Postgraduate School, 1970.

EDWARD NORTON WARD, Manager, Systems Programming (1959), B.A., Univ. of California at Los Angeles, 1952.

DAVID FREDRIC NORMAN, Manager, Operations (1969).

LOIS MAY BRUNNER (1961); B.S., Naval Postgraduate School, 1968.

MICHAEL GARY CORCORAN (1969); B.A., Univ. of California at Santa Cruz, 1969.

HANS WELTER DOELMAN (1967); B.S., Univ. of California at Berkeley, 1956.

RICHARD EUGENE DONAT (1968); B.S., California State Polytechnic College, 1967.

WILLIAM DAVID EHRMAN (1968); B.S., Colorado State Univ., 1965; M.S., 1968.

CLARENCE WILLIAM KELLOGG (1968); A.A., Monterey Peninsula College, 1969.

GERARD PAUL LEARMONTH (1969); B.S., New York Univ., 1966; M.B.A., 1972.

LLOYD GEORGE NOLAN (1971); B.S., Colorado State Univ., 1968.

BERNADETTE REQUIRO PEAVEY (1967); B.A., Univ. of California at Berkeley, 1963.

SHARON DILL RANEY (1964); B.S., California State Polytechnic College, 1964.

KATHRYN BETTY STRUTYNSKI (1967); B.S., Brigham Young Univ., 1953.

ARTURO VALLES (1970); B.S., Trinity Univ., 1957.

ROBERT STEPHEN WALTON (1961); B.S., Massachusetts Institute of Technology, 1949.

PIMPORN CHAVASANT ZELENY (1968); B.S. (Honours), Chulalongkorn Univ. in Bangkok, 1955; M.S., Syracuse Univ., 1958.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School was one of the first institutions to use digital computers in their educational programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic departments. In December, 1969, the Facility was renamed the "W. R. Church Computer Center" in memory of Professor Church, Chairman of the Department of Mathematics (1947-66), who recognized very early the value of computers in education and was instrumental in obtaining the early computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in connection with instruction, research, or administrative activities.

These services are based on an IBM 360, Model 67 computer system which was installed in April, 1967. The present hardware complement includes two Model 67 processing units; four different levels of storage, including 1 million bytes of core, four million bytes on a drum, approximately 291 million bytes on disk devices and 400 million bytes on a data cell unit; four magnetic tape units; two high-speed plotters, thirty remote typewriter terminals, and an IBM 2250 Display Unit with light-pen and programmed function keyboard. The two processors are identical and can access directly, or control, all components of the system including core storage modules, input/output controllers and devices. The resources of the system can be allocated easily to create different operational environments.

The Center offers users two modes of operational services, viz., batch-processing and multi-access time-sharing. Both operating systems support a great variety of programming languages, libraries of subroutines and other software facilities. Language support includes FORTRAN IV, WATFOR, Assembler, COBOL, PL/1, BASIC, ALGOL, and GPSS.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to the computer early in their curricula at the Naval Postgraduate School and encouraged to use it in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered by the Computer Science Group and the Departments of Electrical Engineering, Mathematics, and Operations Research & Administrative Sciences. The School offers two graduate degrees in the computer field, viz., M.S. (Computer Systems Management) since 1963, and M.S. (Computer Science) since 1967.

The Center has a staff of 31 people of whom 16 are mathematician/programmers. The professional staff provides a consulting service in applications programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new programming facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, and numerical analysis.

Two of the six boats available from the School's Sailing Association

THE DUDLEY KNOX LIBRARY

STAFF

GEORGE RIDGELY LUCKETT, Professor and Director of Libraries (1950)*; B.S., Johns Hopkins Univ., 1949; M.S., Catholic Univ., 1951.

PAUL SPINKS, Associate Professor and Associate Director of Libraries (1959); B.A., Univ. of Oklahoma, 1958; M.S., 1959.

EDGAR RAYMOND LARSON, Assistant Professor and Reader Services Librarian (1959); B.A., Univ. of Washington, 1939; B.S., 1950.

GEORGIA PLUMMER LYKE, Reference Librarian (1952); A.A., Hartnell College, 1940.

DIANE SHIRLEY NIXON, Reference Librarian (1969); B.A., California State College, 1968; M.S., Univ. of Southern California, 1969.

JANUSZ IGNACY KODREBSKI, Assistant Professor and Head Catalog Librarian (1956); Diplomat of the National War College, Warsaw, Poland, 1938; M.S., Univ. of Southern California, 1955.

ELSA MARIE KUSWALT, Catalog Librarian (1958); B.A., Univ. of California at Berkeley, 1957; M.L.S., Univ. of Southern California, 1966.

LOUIS OVEN, Catalog Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., 1968; M.A., Univ. of California at Berkeley, 1968.

JAMES HENRY SINDBERG, Catalog Librarian (1972); B.S. (Math), Univ. of Oregon, 1965; B.S. (Educ.), 1974.

NOEL WILLIAM JOHNSON, Assistant Professor and Head Technical Reports Librarian (1970); B.A., Univ. of Nevada, 1949; B.L.S., Univ. of California at Berkeley, 1954.

PASCO DOMENIC COLLELO, Technical Reports Librarian (1973); B.S., Brown Univ., 1951; M.A., California State Univ., San Jose, 1972.

CLEO ELIZABETH PETERSON, Technical Reports Librarian (1958); A.A., Red Oak College, 1938.

FRANCES EMANUELA MARIA STRACHWITZ, Technical Reports Librarian (1970); B.S., Dominican College of San Rafael, 1951; M.A., Univ. of Denver, 1968.

MARY THERESE BRITT, Acquisitions Librarian (1966); B.S., College of St. Catharine, 1947.

JOANNE MARIE MAY, Bibliographer (1971); B.A., Chestnut Hill College, 1964; M.L.S., Villanova Univ., 1967.

**The year of joining the Postgraduate School is indicated in parentheses.*

The Dudley Knox Library, a building of 50,000 square feet, was dedicated in 1972. The collections housed therein serve the research and instructional needs of the community comprising students, faculty and staff of all departments of the Postgraduate School. They embrace an active collection of 153,000 books, bound periodicals and pamphlets, 140,000 technical documents, over 2,500 periodicals and other serial publications currrently received, and 63,000 microfiche. These materials parallel the School's curricular fields of engineering, physical sciences, managerial sciences, operations research, naval sciences, government and humanities.

The Reference Library provides the open literature sources such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It also furnishes facilities for microfilm reading and microfilm printing, for photographic and contact reproduction of printed matter, and for borrowing, from other libraries, publications not held in its collection.

The Technical Reports and Classified Materials Section is the principal repository for technical research documents received by the School. It houses 140,000 classified and unclassified documents, and exercises control over the microfiche collection. A machine information storage and retrieval system that utilizes the Schools's computer facilities is available for bibliographic searches of research and development documents held by the section. An SDI (Selective Dissemination of Information) Service is also available. In addition the Section is now able to perform, via its own remote terminal, computer searches of the data banks of the Defense Documentation Center in Alexandria, Virginia, and thus to provide rapid and efficient access to the 800,000 documents held by the Center.

The Christopher Buckley, Jr., Library is located on the second floor of the Library. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who began donating books to the School for this Library in 1949.

LaMesa Village student housing area and elementary school

CURRICULAR OFFICES and PROGRAMS

CURRICULAR OFFICES AT THE POSTGRADUATE SCHOOL

Title	*Organizational Code*	*AUTOVON*
Administrative Science and Computer Science	36	479-2536
Aeronautical Engineering	31	479-2491
Baccalaureate and Naval Intelligence	38	479-2226
Electronics and Communications Engineering	32	479-2056
Environmental Sciences	35	479-2044
Naval Engineering and Engineering Science	34	479-2033
Operations Research/Systems Analysis	30	479-2786
Weapons Engineering	33	479-2116

CURRICULA AT THE POSTGRADUATE SCHOOL

Curriculum	*Curriculum Number*	*Normal Length*	*Convening Dates*	*Cognizant Curricular Office Code*
Administrative Science (Finance, Personnel, Material)	814, 817	18 mo.	January, July	36
Advanced Science (Mathematics, Physics)	380	24 mo.	March, September	33
Aeronautical Engineering	610	24 mo.	March, September	31
Baccalaureate	461	24 mo.	Final Input 1/74	38
Communications Engineering	600	27 mo.	March, September	32
Computer Science	368	21 mo.	March, September	36
Engineering Acoustics	535	27 mo.	September	33
Engineering Electronics	590	27 mo.	March, September	32
Engineering Science	460	6 mo.	March, September	34
Information Systems (Computer)	367	15 mo.	March, September	36
Information Systems (Telecommunications)	620	18 mo.	March, September	32
Meteorology	372	24 mo.	March, September	35
Naval Engineering	570	27 mo.	March, September	34
Naval Intelligence	825	18 mo.	September	38
Nuclear Science	521	27 mo.	September	33
Oceanography	440	24 mo.	March, September	35
Operational Systems Technology (ASW)	525	24 mo.	March	33
Operations Research/Systems Analysis	360	24 mo.	March, September	30
Systems Acquisition Management	816	18 mo.	March, September	36
Weapons Systems Engineering	530	27 mo.	March, September	33

NOTE: Curricula descriptions are provided on the following pages and are grouped under cognizant Curricular Offices. Curricular Offices appear in alphabetical order. *Additional details on representative curricula may be obtained by calling or writing directly to the Curricular Office concerned using code listed above.*

ADMINISTRATIVE SCIENCE AND COMPUTER SCIENCE PROGRAMS

CURRICULA NUMBERS 367, 368, 814, 816, and 817

WINDOM LAWRENCE ESTES, Commander, U. S. Navy; Curricular Officer; B.S. with major in Mathematics, Naval Postgraduate School, 1963, M.S. in Computer Science, 1970.

GERALD LEE MUSGRAVE, Academic Associate for Information Systems (Computer); B.A., California State Univ., Northridge, 1964; M.S., Michigan State Univ., 1966, Ph.D., 1972.

GARY ARLEN KILDALL, Academic Associate for Computer Science; B.S., Univ. of Washington, 1967; M.S., 1969; Ph.D., 1972.

PETER DEMAYO, Commander, SC, U. S. Navy; Academic Associate for Systems Acquisition Management; B.S., Hofstra Univ., 1958; M.B.A., Univ. of Michigan, 1965.

RICHARD SANFORD ELSTER, Academic Associate for Administrative Science; B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D., 1967.

PETER AIDAN BROWNE, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer; B.S., U. S. Naval Academy, 1963; M.S. in Personnel Administration, George Washington Univ., 1970.

OBJECTIVE—This postgraduate education increases an officer's potential in all assignments throughout his military career, including operational, technical, managerial, and policy-making billets. An officer achieves a sound graduate-level managerial ability; develops, through an insight into the many complex elements of problems, his analytical ability for practical problem-solving; broadens his capacity for original thought and research; acquires diverse professional knowledge; gains an appreciation of the use and value of continuing education; and discovers a new personal confidence that leads to productive achievement throughout his career.

ADMINISTRATIVE SCIENCE (FINANCE, PERSONNEL, MATERIAL) CURRICULA NUMBERS 814 and 817 (GROUP MN)

OBJECTIVE (SPECIFIC)—to provide graduate level education in the managerial skills essential to the professional development of military officers with diverse academic backgrounds. Upon successful completion of the curriculum, the officer will have a sound understanding of the financial processes of major industries in their dealings with the private and public sector; an appreciation of capital budgeting and management of the dollar resources of the Services; broad knowledge of the inventory and allocation processes and the elements of the procurement cycle, including contract administration; and a deep understanding of individual, group, and organizational behavior. A graduate of this curriculum is thus prepared to understand and make the managerial decisions critical to effective development and utilization of complex military systems.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above-average grades is required. Completion of at least one semester of college mathematics at or above the level of college algebra or trigonometry is considered to be the minimum mathematical preparation.

DESCRIPTION—The curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration area into an understanding of the process by which the missions of the Navy are accomplished. Subspecialty concentration areas currently available are Personnel/Manpower, Financial Management, Material/Logistics, Management Science (designed primarily for USCG Officers), and Economic Analysis. Officers from U. S. and Allied military services are enrolled in this curriculum. Officers successfully completing the program will be awarded the degree of Master of Science in Management. In addition, Naval officers who successfully complete any of the approved programs are awarded a subspecialty billet code appropriate to their concentration area. Matriculation for the program occurs semiannually in July and January.

Naval officers in the MSC Management (#814) curriculum complete the Administrative Science (#817) curriculum at the Naval Postgraduate School, Monterey, CA, followed by approximately 5 months of additional study at the Transportation Management School, Oakland, CA.

The curriculum is divided into Fundamentals and Graduate Programs. The Fundamentals Program is designed to bring all students up to a common level before entry into graduate study. This portion of the program varies in length from zero to two quarters, depending upon the student's background, prior academic work, and time away from academic endeavors. The Graduate Program normally requires four quarters to complete. A student's maximum program may not exceed six quarters.

Classroom instruction is supplemented by the weekly guest lecturer seminar, MN 0001, which affords the student an opportunity to participate in discussions of pertinent topics with senior military officers, business executives, and prominent educators.

Officers from the U. S. Services as well as foreign officers start the curriculum with widely varied academic backgrounds and complete intellectually demanding courses in many disciplines. Upon entry into the program, each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Administrative Science curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the Fundamentals material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

Fundamentals Program

This portion of the program provides the necessary background and tool subjects for successful pursuit of the graduate program. Credit transfer and course validation is especially applicable to this area.

The model curriculum include the following comprehensive fields:

Mathematics: provides the quantitative tools required for successful pursuit of the remaining courses.

MA 2040	Matrix Algebra	2-0
MA 2305	Differential Calculus	3-0
MA 2306	Integral Calculus	2-0
PS 3005	Probability	3-0

Economics: provides an introduction to economic theory and decision processes.

MN 2031	Economic Decision Making	4-0
MN 3140	Microeconomic Theory	4-0

Accounting: provides the necessary background in basic accounting principles, costing, and budgeting.

MN 2150	Financial Accounting	4-0
MN 3161	Managerial Accounting	4-0

Organization/Behavior: provides an introduction to personal/group behavior and the relationship to organizational management.

MN 2106	Individual and Group Behavior	4-0
MN 3105	Organization and Management	4-0

Graduate Program

The graduate portion of the curriculum consists of required courses, elective courses in the student's subspecialty concentration area, at least one free elective, and thesis research. Any transfer of graduate credit which may be applicable is used to reduce the number of courses in this area.

Required Courses:

MN 3101	Personnel Management and Labor Relations	4-0
MN 3172	Public Policy Processes	4-0
MN 3183	Management Information Systems and the Computer	4-0
MN 3211	Operations Analysis for Management I	3-2
MN 3212	Operations Analysis for Management II	3-2
MN 4105	Management Policy	4-0
MN 4145	Systems Analysis	4-0
MN 4191	Decision Analysis	4-0
HG 3002	Human Resource Development	2-4
CS 0113	COBOL Programming	3-0

Elective Courses: At least one free elective is available to broaden the student's education in an area of his interest. Three electives must be taken in the student's subspecialty concentration area. Selection of elective is done in cooperation with and approval of the Curricular Office. The electives in each of the five concentration areas include:

Personnel/Manpower

MN 3001	Behavior Research Methodology	4-0
MN 3111	Industrial Psychology	4-0
MN 4112	Personnel Selection and Classification	4-0
MN 4113	Personnel Training and Development	4-0
MN 4114	Personnel Performance Evaluation	4-0
MN 4147	Industrial Relations	4-0
MN 4115	Personnel Motivation	4-0
MN 3120	Planning and Control	4-0
MN 3125	Organizational Behavior and Administration	4-0
MN 4123	Organization Development	3-2

Financial Management

MN 3251	Accounting Theory and Standards	4-0
MN 3165	Selected Topics in Accounting and Financial Management	2-0 to 5-0
MN 4151	Internal Control and Auditing	4-0
MN 4152	Decision Making for Financial Management	4-0
MN 4153	Seminar in Accounting and Control	4-0
MN 4154	Seminar in Financial Management	4-0
MN 4161	Controllership	4-0
MN 4162	Cost Accounting	4-0
MN 4165	Selected Topics in Accounting and Financial Management	2-0 to 5-0
MN 4181	Application of Management Information Systems	4-0

Material/Logistics

MN 3371	Procurement and Contract Administration	4-0
MN 3372	Physical Distribution and Supply Systems	4-0
MN 3373	Transportation Management	4-0
MN 3374	Production Management	4-0
MN 3376	Selected Topics in Material Logistics	2-0 to 5-0
MN 4371	Procurement Policy	4-0
MN 4374	Seminar in Transportation Management	4-0
MN 4376	Seminar in Material/Logistics	4-0

Management Science

MN 3214	Operations Research Methodology	4-0
MN 3215	Selected Topics in Management Science	2-0 to 5-0
MN 3654	Investigative Methods of Economics I	4-0
MN 4181	Application of Management Information Systems	4-0
MN 4192	Workshop in Management Science	2-0 to 5-0
MN 4193	Selected Topics in Management Science	2-0 to 5-0
MN 4645	Investigative Methods of Economics II	4-0
OA 3604	Linear Programming	4-0
OA 3620	Inventory I	4-0
OA 4634	Games of Strategy	4-0

Economic Analysis

MN 3135	Selected Topics in Economics	2-0 to 5-0
MN 3142	International Trade and Development	4-0
MN 3146	Comparative Economic Systems	4-0
OA 3610	Utility Theory and Resource Allocation	4-0
MN 3645	Investigative Methods and Economics I	4-0

MN3760	Manpower Economics	4-0
MN3770	Economics of Labor and Industrial Organization	4-0
MN4142	International Trade and Development Policy	4-0
MN4146	Public Expenditure Analysis	4-0
MN4645	Investigative Methods of Economics II	4-0
MN4931	Macroeconomic Theory and Policy	4-0
MN4941	Microeconomic Theory and Policy	4-0
MN4945	Selected Topics in Economics	2-0 to 5-0
OA 4614	Methods and Practice of Systems Analysis	4-0

Thesis Research: Twelve quarter hours are allocated, four in the next to final quarter and eight in the final quarter. The thesis provides the student with the opportunity to apply graduate education and experience to a challenging problem of interest to his service. The thesis must be in the student's subspecialty concentration area.

COMPUTER SCIENCE CURRICULUM
CURRICULUM NUMBER 368
(GROUP CS)

OBJECTIVE (SPECIFIC)—to provide graduate level education in applied computer science as a foundation for professional development in support of the application of computers to all aspects of military operations. This education is designed to develop technically qualified officers with a theoretical background in computer science supported by appropriate computer-related experience. Upon successful completion of the curriculum, the officer will have the knowledge and skills necessary to specify, evaluate, and manage the design of computer systems and provide technical guidance in applications.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above-average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Undergraduate majors in applied sciences or engineering are highly desirable.

DESCRIPTION—This curriculum is an interdisciplinary program integrating mathematics, probability, statistics, operations research, and computer science. Computer science is a relatively new academic discipline, concerned with the representation, storage, and manipulation of data by techniques and devices applicable to a wide variety of problems. Emphasis is on programming systems and systems design, particularly those aspects of the theory of relevance to military applications. Officers from U. S. and Allied military services are enrolled in this curriculum. Students successfully completing the program will be awarded the Master of Science in Computer Science. In addition, Naval officers will be awarded the appropriate subspecialty billet code. Matriculation for the program occurs semiannually in September and March.

The curriculum is divided into Introductory and Graduate Programs. The Introductory Program is designed to bring all students up to a common level before entry into graduate study. This portion of the program varies in length from one to three quarters, depending upon the student's background, prior academic work, and time away from academic endeavors. The Graduate Program requires three to four quarters to complete. A student's maximum program may not exceed seven quarters.

Classroom instruction is supplemented by practical experience in the Naval Postgraduate School computer facilities. The weekly guest lecturer seminar, CS 0001, affords the students an opportunity to participate in discussions of computer topics with senior military officers, Department of Defense officials, and prominent educators.

Upon entry into the program, an evaluation of each student's prior academic work and related military experience is coordinated through the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Computer Science curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the introductory or preparatory material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

Introductory Program

This portion of the curriculum provides the necessary background and tools in preparation for the graduate curriculum. Credit transfer and course validation is especially applicable to this area.

The model curriculum includes the following comprehensive fields:

Classical Mathematics: provides the quantitative tools required for successful pursuit of the remaining courses.

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
MA 2121	Differential Equations	4-0
MA 3232	Numerical Analysis	3-2

Logic: develops logical and reasoning abilities for detailed analysis work.

MA 2025	Logic, Sets, and Finite Mathematics	4-0
MA 3026	Topics in Discrete Mathematics	4-0
CS 3601	Automata and Formal Languages	3-0

Computer Fundamentals: foundation work in programming and digital computer theory.

CS 0110	FORTRAN Programming	3-0
CS 2110	Introduction to Computers and Programming for Computer Science Majors	3-2
CS 3111	Fundamental Concepts in Structural Programming Languages	4-0
CS 3112	Operating Systems	4-0
CS 3200	Structure of Digital Computers	4-0

Probability, Statistics, and Operations Research: provides an understanding of the basic techniques.

PS 3401	Intermediate Probability and Statistics I	4-0
PS 3402	Intermediate Probability and Statistics II	4-0
OS 3205	Operations Research for Computer Scientists	4-0

Graduate Program

The graduate portion of the curriculum consists of required courses, electives, and thesis research. Any trans-

fer of graduate credit which may be applicable is used to reduce the number of courses taken in this area.

Required Courses: Included are those subjects which constitute a basis for modern computer theory and practice. These courses provide the necessary background for subsequent thesis research.

CS 3201	Computer Systems	4-0
CS 3204	Data Communications	4-0
CS 3300	Information Structures	3-0
CS 4113	Compiler Design and Implementation	3-2
CS 4202	Interactive Computation Systems	3-2
CS 4310	Non-numerical Information Processing	4-0
CS 4900	Advanced Topics in Computer Science	3-0
CT 4182	Data Processing Management	4-0
OA 3653	System Simulation	4-0

Elective Courses: Elective courses are available to broaden the student's education in an area of interest. Selection of electives is done in cooperation with, and approval of the Curricular Office. Electives are available in areas such as management, electrical engineering, operations analysis, mathematics, and computer science.

Thesis Research: Sixteen quarter hours are allocated for thesis research, eight in each of the student's final two quarters of the program. Emphasis is on military applications and research in the computer science field.

INFORMATION SYSTEMS (COMPUTER) CURRICULUM CURRICULUM NUMBER 367 (GROUP CT)

OBJECTIVE (SPECIFIC)—to provide interdisciplinary graduate level education as a foundation for professional development of the managerial and technological skills essential to the successful implementation and effective utilization of computer-based systems in military operations. This interdisciplinary program is designed to develop technically qualified officers who have an understanding of advanced computer technology and the ability to effectively employ this technology. Upon successful completion of the curriculum, the officer will have the knowledge, skills, and practical understanding necessary to evaluate the changes and advances in the computing field. In addition he will be able to determine the applicability of various computer systems to military operations and he will be able to understand and make the critical management decisions that are needed in the development and utilization of complex computer-based systems.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above-average grades in mathematics is required. Completion of two semesters of college mathematics, at or above the level of college algebra, is considered to be minimal preparation. Completion of differential and integral calculus is highly desirable.

DESCRIPTION—The Information Systems (Computer) curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, computer science, behavioral science and basic management techniques into an understanding of the management of large computer centers. Elective courses are available to permit a student to pursue his own special area of interest in depth. Officers from U. S. and Allied military services are enrolled in this curriculum. Students successfully completing the program will be awarded the degree of Master of Science in Computer Systems Management. In addition, Naval officers will be awarded the appropriate subspecialty billet code. Matriculation for the program occurs semiannually in September and March. A student's maximum program may not exceed five quarters.

Classroom instruction is supplemented by the weekly guest lecturer seminar, CT 0001, which affords the student an opportunity to participate in discussions of computer/managerial topics with senior military offiicers, business executives, and prominent educators.

Upon entry into the program, each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Information Systems (Computer) curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the background or preparatory material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

The model curriculum includes the following comprehensive fields:

Mathematics: provides the quantitative tools necessary for successful pursuit of the remaining courses.

MA 2300	Math for Management	5-0
PS 3011	Probability and Statistics for Management I	5-0
PS 3012	Probability and Statistics for Management II	4-0

Accounting and Economics: provides fundamentals necessary for computer systems management.

MN2150	Financial Accounting	4-0
MN3161	Managerial Accounting	4-0
MN3141	Microeconomics	4-0

Computer Science: provides understanding and appreciation of computers and computer systems.

CS 0110	Fortran Programming	3-0
CS 2103	Introduction to Computers and COBOL Programming	4-0
CS 3111	Fundamental Concepts in Structural Programming Languages	4-0
CS 3112	Operating Systems	4-0
CS 3200	Structure of Digital Computers	4-0

Computer Systems Management: provides basic management techniques as applied to the management of large computer centers.

MN2106	Individual and Group Behavior	4-0
MN3105	Organization and Management	4-0
MN3170	Defense Resource Allocation	4-0
CT 3210	Operations Research for Computer Systems Managers	4-0
CT 4182	Data Processing Management	4-0
CT 4185	Computer-based Management Information Systems	4-0

Electives: provides an opportunity to explore a subject in depth to meet curriculum sponsor's needs and to

develop professionally. Selection of electives is done in cooperation with, and by approval of, the Curricular Office. At least four electives must be taken, two of them at the 4000 level. If desired, a thesis may be undertaken in lieu of two electives. These electives include additional offerings in computer science, operations research, personnel/manpower, financial management, material/logistics, and economics.

SYSTEMS ACQUISITION MANAGEMENT CURRICULUM CURRICULUM NUMBER 816 (GROUP SM)

OBJECTIVE (SPECIFIC)—to provide graduate level education in the fundamental concepts, methodology, and analytical techniques required for the life cycle management of the planning and acquisition of defense systems. This curriculum is designed to meet the military's expanding needs for acquisition management personnel at headquarters and related activities having system acquisition management responsibilities.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above-average grades is required. Completion of differential and integral calculus is considered minimal mathematical preparation. Undergraduate majors in engineering or physical science are highly desirable, though other majors may be acceptable if the officer's experience demonstrates acquired technical competence.

DESCRIPTION—The curriculum consists of basic core courses which provide the fundamental disciplines essential to the acquisition process. Advanced courses are concerned with the structure of acquisition management in the Department of Defense and the decisions required of the acquisition manager. An appreciation of the forces at work in industry and within the executive and legislative branches of government and how these forces impact on systems acquisition policies and procedures is presented throughout the program. Elective courses are available to enable the student to gain additional knowledge in acquisition areas of particular interest. Classroom instruction stresses theoretical concepts as well as real world problems solving through lectures, case studies, problem exercises and computer simulation exercises. Field trips to industrial and military activities are also utilized to reinforce and further develop classroom concepts.

This curriculum is available only to officers from the U. S. military services. Upon successful completion, graduates are awarded the Master of Science in Management and Naval officers are awarded the appropriate subspecialty billet code. Matriculation for the program occurs semiannually in September and March. A student's program may not exceed six quarters in length.

Classroom instruction is supplemented by the weekly guest lecturer seminar, SM 0001, which affords the student an opportunity to participate in discussions with senior military officers, industry executives, and officials from governmental agencies.

Upon entry into the program each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Systems Acquisition Management curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the material has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the background or preparatory material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

The model curriculum includes the following discipline fields:

Quantitative Methods: provides the tools necessary for successful pursuit of the remaining courses.

OS 3201	Fundamentals of Operations Analysis	4-0
OS 3202	Methods of Operations Analysis/ Systems Analysis	4-0
OS 3203	Survey of Operations Analysis/ Systems Analysis	4-0
SM 3306	Systems Effectiveness Concepts and Methods	4-0
MN4145	Systems Analysis	4-0
CS 0110	Fortran Programming	3-0

Financial Management: provides an understanding of government and corporate finance.

MN2150	Financial Accounting	4-0
MN3161	Managerial Accounting	4-0
MN3143	Managerial Economics	4-0
SM 4302	Public Expenditure Policy & Analysis	4-0

Life Cycle Management: from program conception through acquisition to replacement.

SM 3301	Introduction to Systems Acquisition	4-0
SM 3302	Fundamentals of Project Management	4-0
MN3374	Production Management	4-0
SM 4301	Systems Engineering Management	4-0
SM 4303	Procurement Planning & Negotiation	4-0
SM 4304	Contract Administration	4-0
SM 4305	Logistic Support	4-0

Personnel: introduction to the basic principles of effective personnel management in government and industry.

MN2106	Individual and Group Behavior	4-0
MN3101	Personnel Management and Labor Relations	4-0

Electives: provides an opportunity to pursue an area in depth. Selection of electives is done in cooperation with and approval of the Curricular Office. At least one of the available electives must be from the Financial Management area. The remainder may be chosen from the following broad areas:

- Accounting
- Financial Analysis
- Organizational Behavior
- Industrial Relations
- Operations Analysis
- Management Information Systems
- Management Policy
- Performance, Conduct and Structure of the Defense Industry

Thesis Research: Twelve quarter hours are allocated for thesis research, four in each of the student's final three quarters of the program. Emphasis is on military applications in the acquisition field.

AERONAUTICAL ENGINEERING PROGRAMS

CURRICULUM NUMBER 610

DONALD WILLIAM MATHEWS, Captain, U. S. Navy; Curricular Officer; B. S. in Engineering, Univ. of California at Berkeley, 1953; B. S. in Aeronautical Engineering, Naval Postgraduate School, 1960; Ae.E., Stanford Univ., 1961; Armed Forces Staff College, 1966.

ROBERT DIEFENDORF ZUCKER, Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

JAMES BARNETT POLAND, Commander, U. S. Navy; Assistant Curricular Officer; B.S., U. S. Naval Academy, 1953; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1967; M.S. in Management, Naval Postgraduate School, 1974.

OBJECTIVE—To provide advanced knowledge and accelerated professional development for aviation officers as a cornerstone in their career dealing with continuing challenges in all aspects of the life cycle of naval aircraft and weapons systems. This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments and policy-making positions.

Officers start with many different academic backgrounds and complete intellectually demanding courses in a wide variety of subjects. In addition, the programs include completion of an aviation-oriented thesis project under the personal guidance of a faculty advisor, award of appropriate graduate degrees, and, for many, a practical work experience tour at a Navy or civilian aviation industrial activity. As a result, naval officers develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their naval career.

QUALIFICATIONS FOR ADMISSION—In accordance with the current edition of OPNAV Note 1520, aviation naval officers are selected for Aeronautical Programs on the basis of their professional performance and potential for advanced graduate level studies. Normally students receive orders to the Curriculum after completion of their first operational tour and therefore have been away from college approximately five years. Since high performing aviation naval officers have many different academic backgrounds, there are several ways to prepare for graduate level studies in Aeronautics. In each case the emphasis for qualification is on currently demonstrated academic performance at the Naval Postgraduate School as a guide to preparing an individualized program of study to insure a high probability of success for the officer.

DIRECT INPUT—The entrance requirement is generally a baccalaureate in engineering earned with above-average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering, but who have had adequate coverage in the basic physical and mathematical sciences.

INDIRECT INPUT—Many high performing naval officers have relatively poor previous academic records, yet show evidence of undeveloped academic potential. Frequently, in these cases, Graduate Record Examination (GRE) results are an excellent indicator of aptitude for this program. Students with a baccalaureate who do not meet the requirements for direct input receive orders via Engineering Science (610 via 460) for one or more quarters to prepare for the Aeronautics Program. Direct input students who require additional refresher courses may also join this group in order to develop a strong academic foundation.

DESCRIPTION—Over the years Aeronautical Programs have served the Navy and aviation officers by providing graduate level interdisciplinary programs leading to Aero subspecialty codes and several different level academic goals. The curriculum is tuned to Navy needs and, as a lesser included part, also satisfies degree requirements established by appropriate academic departments. Degrees presently include MSAE, MSAE and MS Management, Ae.E., and Ph.D. A one-year non-degree certificate of completion is also available.

Included in the preparatory program is the study of aeronautics aimed at increasing professional knowledge in the officer's warfare specialty of Naval Aviation and academic preparation for rigorous graduate work. These objectives are important because of the large number of valuable high performance career officers with previous academic performance below normal graduate school standards.

Aeronautical Programs are multi-disciplinary and have included many "specialty areas" under the Aero Subspecialty Code. Hence there are a large number of well-defined billets at all ranks forming a viable career progression for top quality multi-disciplinary officers who flow in and out of specialized aviation billets throughout the Naval Material Command and associated field activities. Historically, this sound billet community is one reason why Aero graduates have formed successful career patterns in the past. The present collection of specialty areas includes traditional Flight Dynamics, Gas Dynamics, Propulsion, and Structures. In addition, Aero specialty areas include study from curricula such as Electronics, Computer Science, Air Weapons, and Physics. With the Dual Masters program, Management is also included as a specialty built on a strong technical foundation. Consequently, the Aero program provides the opportunity for aviation warfare specialists to study in most areas using general engineering and scientific principles as a cornerstone.

Unrestricted line officers who successfully complete any of the approved programs are awarded an aeronautical subspecialty billet code and subsequently may qualify for the promotion-enhancing designation of "Proven Subspecialist" in accordance with the Operational Technical Managerial System (OTMS). Officers desiring to specialize in a technical management career become prime candi-

dates for Aeronautical Engineering Duty in the Restricted Line. Restricted line officers receive the same subspecialty billet code as URL officers, but specialize in technical management assignments.

The URL officer primarily seeks this professional development to enhance his opportunity for the major career goal of Aviation Command and may use his education and subspecialty to qualify for the additional career goal of Major Project Manager for naval aviation weapon systems. Officers transferring to the Restricted Line (AED) usually seek career goals of Major Project Manager and Command of Naval Air Rework Facilities, Naval Plant Representative Offices, Naval Laboratories, and RDT&E Centers.

Officers qualified for the Direct Input, convening twice yearly in the March and September quarters, complete a rapid preparatory period at the beginning of the program. Indirect Input students have completed a variety of courses in mathematics, and engineering science to eliminate academic deficiencies and complete a slower paced preparation program. The combined group completes upper division courses providing a major increase in professional knowledge in areas of mathematics, fluids, solids, and aerodynamics in preparation for graduate level studies. The emphasis in the preparatory period is to round out and update aeronautical engineering background, demonstrate current potential for full graduate school studies and entry into a graduate degree program, and identify specific areas of interest for thesis study and individualized specialization.

Aeronautics students accepted into a graduate program complete five quarters of graduate work that includes Departmental requirements for the degree of Master of Science in Aeronautical Engineering. Students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program and obtain the Master of Science degree upon completion of four quarters of work, including an acceptable thesis.

Officers demonstrating particularly strong academic performance in the preparatory program may enter a two year graduate program leading to both the Master of Science in Aeronautical Engineering and the advanced degree of Aeronautical Engineer. This program includes a six-week experience tour at a Navy or civilian aviation industrial activity. Also, a few officers with strong academic performance may complete the two-year Dual Masters program. In this program the student completes requirements for the Master of Science in Aeronautical Engineering and Master of Science in Management. An exceptionally well qualified officer may be selected for the Ph.D. program.

Students who do not enter a graduate program complete a one-year program including the technical preparatory courses, professional development courses, and studies leading to qualification as an Aviation Safety Officer. This non-degree program also leads to an Aeronautical E-coded billet qualification and academic credits available for use in a continuing education program at future duty stations.

All Aero graduates will receive subspecialty qualification codes (811XP) as listed in the Annual Officer Billet Summary (NAVPERS 15993 and 15994). Subsequent duty may lead to qualification as a "Proven Subspecialist" in accordance with the Operational Technical Managerial System (OTMS). Dual Masters graduates are prime candidates for WSAM coding in accordance with BUPERINST 1040.2 series and receive dual subspecialty qualification codes (811XP/914OP).

Preparatory Program

Preparation for graduate study normally includes the courses listed below. Each student's prior academic transcript will be evaluated for possible validation of courses in areas where a strong record of achievement is evident. Validation or credit by examination is also possible. The remaining courses will be scheduled with a normal load of 16-18 credit hours per quarter.

Mathematics Sequence

MA 1100	Calculus Review	4-0
MA 2047	Linear Algebra and Vector Analysis	4-0
MA 3130	Differential Equations	4-0
MA 3173	Complex Variables and Laplace Transforms	4-0

Solids Sequence

AE 2021	Aero Structures I	3-2
AE 2022	Aero Structures II	3-2
AE 3015	Engineering Dynamics	3-2

Fluids Sequence

AE 2041	Basic Fluid Mechanics	3-2
AE 2042	Engineering Thermodynamics	3-2
AE 3043	Fundamental Concepts of Gasdynamics	3-2

Flight Dynamics Sequence

AE 2031	Vehicle Aerodynamics I	3-2
AE 2032	Vehicle Aerodynamics II	3-2
AE 3033	Vehicle Aerodynamics III	3-2

Laboratory Sequence

AE 2801	Introduction to Aero Laboratories	0-3
AE 3811	Solid Mechanics Laboratory	0-3
AE 3851	Gasdynamics Laboratory	0-3

Students who desire to pursue the Aeroelectronics specialty in their graduate program need either an undergraduate background in electrical engineering or substitution of basic EE courses for the above Solids Sequence.

Graduate Study

After the preparatory program, students have an understanding of the various specialty areas in the Aeronautical Engineering Curriculum. Selection for various graduate programs is made based on academic performance, career availability, and personal career plans of the student. At this point students select a thesis topic and prepare their graduate level program of study in consultation with their thesis advisor and the Academic Associate. Sufficient courses are available for in-depth coverage in the following areas:

FLIGHT DYNAMICS includes coverage of the stability and control parameters of a flight vehicle in both pilot-controlled and automatic-controlled modes. Both manned and unmanned vehicles are investigated. Topics include automatic landing systems, missile control, and optimal

design. An instrumented airplane is used for flight evaluation.

In *GASDYNAMICS*, operation of flight vehicles in the broad spectrum ranging from hovering flight to hypersonic reentry is investigated, with particular emphasis being placed on the behavior of the gas (air or near-space) in which the vehicle is operating. Subsonic, transonic, supersonic, hypersonic, and plasma flows are covered in detail.

FLIGHT PROPULSION develops fundamentals of fluid dynamics, thermodynamics, and turbomachinery to provide a generalized flight propulsion background. Emphasis on thesis work is directed toward turbomachinery or solid propellants.

For *FLIGHT STRUCTURES*, a study in depth of the mechancis of solids is followed by investigations of the behavior of structural components under conditions of static and dynamic (including aero-elastic) loads (both steady and non-steady). Free, forced, and self-excited vibrations; flutter, gusts, buffet, and stall effects; and wing divergence and control reversal are typical of the topical coverage.

In the *AIR WEAPONS* specialty, the studies of chemical explosives and blast and shock effects are emphasized and supplement coverage of aeronautics courses to prepare the graduate to work in the sub-area of conventional ordnance in air weapons systems.

The *AERO COMPUTER SCIENCE* specialty provides knowledge in depth in computer-flight vehicle interface in operation of modern and project air weapons systems. Computer technology, capability, and applications to the flight vehicle and its mission are stressed.

An *AERO SPACE PHYSICS* specialty includes the study of electro-optics, electromagnetics, quantum mechanics, and space and near-space physics. This specialty sequence prepares the graduate to participate in any of several areas in Navy programs involving missile and space technology.

The *AEROELECTRONICS* specialty builds upon a background of aeronautics courses. In-depth studies in electrical and electromagnetics fundamentals and applications in electronics prepare the graduate to serve as a specialist in avionics of both manned and unmanned flight vehicles in naval air weapons systems programs.

Thesis Research

All graduate students complete an aviation oriented thesis as one of the most important parts of their advanced program. This acts as a synthesis for their graduate education. Master's degree programs include the equivalent of three course slots for this research whereas Engineer degree programs allow five course slots. These are normally spread over the latter quarters of each program.

Professional Development Courses

In addition to those technical courses that form the structure of the graduate program and meet degree requirements, each student takes courses which are particularly relevant to Navy needs and career development. These range from eight to twelve in number and may be selected in various combinations of single courses or sequences from areas such as the following:

Avionics
Aviation Safety
Computer Science
Operations Analysis
Material Science
Financial Management
Systems Reliability

Experience Tours

All Engineer degree programs include a six-week practical engineering work experience at a Navy or civilian aviation industrial activity. Normally, these tours are taken after about one year of graduate course work and are oriented in the general field of the student's research project. On an individual basis it is also possible to arrange for one of these practical experience tours in the Masters degree program.

BACCALAUREATE AND NAVAL INTELLIGENCE PROGRAMS

CURRICULA NUMBERS 461 and 825

DONALD THOMAS FITZGERALD, Commander, U. S. Navy; Curricular Officer for Baccalaureate Programs; B.S., Univ. of Utah, 1959.

ROBERT WILLIAMS CHAPIN, JR., Lieutenant Commander, U.S. Navy; Curricular Officer for Naval Intelligence Program and Assistant Curricular Officer for Baccalaureate Programs; A.B. in French, Kenyon College, 1959; M.S. in Management, Naval Postgraduate School, 1973

RAYMOND KENNETH HOUSTON, Academic Associate for B.S. Program; B.S., Worcester Polytechnic Institute, 1933; M.S. 1939.

STEPHEN GOTTSCHALK, Academic Associate for B.A. Program; B.A., Occidental College, 1962; M.A., Univ. of California at Berkeley, 1963; Ph.D., 1969.

FRANK MICHAEL TETI, Academic Associate for Naval Intelligence Program; B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; Ph.D., Syracuse Univ., 1966, M.P.A., 1972.

MICHAEL ANDREW ROSE, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer for Baccalaureate Programs; B.S., California Maritime Academy, 1961; B.A. with major in Government (International Relations), Naval Postgraduate School, 1970.

The Baccalaureate Curriculum will be phased out during 1974-75. The final input into the curriculum was received in January 1974. For details of the curriculum, the 1972-74 Catalogue of the Naval Postgraduate School should be consulted.

NAVAL INTELLIGENCE CURRICULUM
CURRICULUM NUMBER 825

OBJECTIVE—To provide advanced education in the field of Naval Intelligence. This curriculum provides a broad graduate-level education in science and engineering, national security affairs, analytical methods, and management techniques in order to further the creative application of these disciplines to the naval intelligence process. Original thinking and professional growth are emphasized by a program of study based upon the growing strategic importance of the U. S. Navy, the complex environment in which the naval intelligence officer works, and the increasing burdens upon the intelligence community. This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments and policy making positions. Naval officers develop sound graduate-level competence in national security affairs, technological aspects of naval intelligence, and analytical and management techniques. They develop a new appreciation for continuing education, acquire a diverse professional knowledge, and become aware of the many complex elements of naval as well as national problems. They develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their naval career. Upon graduation, naval officers are awarded the intelligence subspecialty billet code.

More specifically, the objectives of the curriculum are to provide the students with advanced education in the following areas:

1) the security interests of the United States and other major international actors, with particular emphasis on the military, economic, political, and social factors which shape and affect their interests and capabilities;

2) the vocabulary, resource material, and basis of operation of military systems and subsystems which allow the incorporation of technical and environmental information into the solution of intelligence problems;

3) an understanding of the strengths and weaknesses of current military systems (U. S. and U. S. S. R.) and areas of probable improvement within the next 10 to 15 years;

4) methods of analysis applicable to the intelligence process, with particular emphasis upon forecasting and threat assessment;

5) problems in the administration and dissemination of intelligence information, and the management of the intelligence process;

6) techniques of interpersonal and group communication;

7) In addition, students will be kept abreast of developments in naval intelligence through periodic scheduled briefings.

QUALIFICATIONS FOR ADMISSION—This curriculum is open only to officers of the U. S. Armed Forces. Officers must have a baccalaureate degree with a minimum overall grade average of C+. There is no restriction upon a prospective student's undergraduate major. Completion of a course in college algebra with a C or better is required. A course in differential calculus is desirable but not mandatory. Of equal importance as an admission criteria is a demonstrated high degree of performance in a warfare or restricted line specialty. All students must be eligible for access to sensitive intelligence information. Questions on security requirements can be addressed to the Curricular Officer, Naval Intelligence Program, Naval Postgraduate School, 93940. Telephone (408) 646-2228 or AUTOVON 479-2228.

DESCRIPTION—The curriculum begins in the second academic quarter of each year in late September. The curriculum leads to a Master of Arts degree in Naval Intelligence. Because of the necessarily fixed sequence of some of the courses and the demanding course load, it is usually not possible to complete the curriculum in less time.

In addition to the academic degree requirements set forth in this catalogue under the Department of Government and Humanities, the curriculum sponsor, the Naval Intelligence Command, has certain requirements which must be satisfied by validation of course work. These requirements reflect the needs of the naval intelligence community for officers with postgraduate education in a wide variety of academic disciplines. Because of the pervasive nature of these requirements and in order to insure that all graduates are equally qualified, all

students must complete a common core of instruction or validate the required courses. From the point of view of time and effort, these requirements exceed the academic requirements for a degree. The core requirements are all the courses listed at the end of this section.

By the very nature of the objectives described above, the curriculum is interdisciplinary in approach. The academic disciplines involved in the curriculum include the following: political science, mathematics, management, operations analysis, English, speech, oceanography, meteorology, electrical engineering, physics, computer science, and economics. For purposes of program management, coordination, curriculum development, and visibility, allied disciplines have been grouped into four "sequences" of courses. These sequences provide the basic structure of the curriculum.

Each student is required to submit a satisfactory thesis as a requirement for his degree. The purpose of the thesis is to serve as a vehicle to integrate the many disciplines in the curriculum, to demonstrate competence in original research and thinking, and to promote searching analyses of intelligence problems of interest to the students and the intelligence community. A reduced course load in the last two quarters provides time for thesis research. In addition, a two week TAD period allows students to discuss their research programs with interested staff officers and to locate data sources in the Washington, D.C., area.

Because of the requirements already discussed for graduates of the program to have a high degree of educational commonality, there is only a limited opportunity for flexibility and diversification within the curriculum. Two electives are provided in the fifth and sixth quarters. A choice is also available between two core courses in the sixth quarter. Additionally, students are encouraged to concentrate or diversify their studies by validating courses which they recently completed or which are within their major field of study and by substituting other courses from the catalogue. The validating process—which includes, in most cases, an examination along with the approval of the curricular officer, academic associate, and department chairman concerned—certifies that the student already has about 90% of the knowledge requirements of a course and is therefore not required to take it. Within the established framework, the student assembles his own program of study by judiciously substituting courses for ones he has validated, by carefully selecting his electives, by choosing the appropriate option in the sixth quarter, and by selecting a thesis topic in the same area as his electives. Any course which is scheduled to be taught and for which the student qualifies may be selected as an elective. Each student's program must be approved by the Chairman of the Department of Government and Humanities before the end of the third quarter of the curriculum.

NAVAL TECHNOLOGY SEQUENCE

The naval technology sequence has as its objective to provide the intelligence officer with knowledge of the vocabulary, resource material, and applications of scientific and technical information relevant to military systems. Environmental and physical phenomena are described at a nonmathematical level.

SE	2001	Concepts of Environmental Science .(4-0)
SE	2002	Concepts of Science and Engineering I .....(4-0)
SE	2003	Concepts of Science and Engineering II .....(4-0)
SE	3004	Survey of Military Technology: Concepts and Applications I .....(4-0)
SE	3005	Survey of Military Technology Concepts and Applications II .....(4-0)
SE	4006	Special Topics in Technological Assessment (Option) .....(4-0)

SECURITY AFFAIRS SEQUENCE

The security affairs sequence has as its objective to provide the intelligence officer with knowledge of the vocabulary, resource material, and application of political and social information to analyses of U. S. security interests. Relevant historical data and the present security interests of the U. S. are examined vis-a-vis the security objectives of other major international actors.

GV	2262	Theory and Practice of International Politics .....(4-0)
GV	3061	American National Security Policy ..(4-0)
GV	3400	Problems of Government and Security in the Soviet Union .....(5-0)
GV	3610	Problems of Government and Security in East Asia and the Pacific Ocean .....(5-0)
GV	3420	Soviet Maritime and Naval Strategy .(5-0)
GV	4273	Special Topics in American Security and Foreign Policy .....(4-0)

ANALYTICAL AND MANAGEMENT SEQUENCE

The analytical and management sequence has as its objective to provide intelligence officers with knowledge of the methods, technology, and limitations of analytical tools and management techniques applicable to the naval intelligence process.

MA	2300	Mathematics for Management .....(5-0)
PS	3000	Probability and Statistics for Naval Intelligence and Communications Management ....(5-0)
OS	3207	Operational Analysis for Naval Intelligence .....(4-2)
CS	2105	Survey of Computers and Programming .....(4-0)
MN	2030	Introduction to Economics .....(4-0)
GV/OS	3062	Intelligence Data Analysis .....(4-2)
GV/OS	4063	Forecasting, Threat Analysis and Net Assessment .....(4-0)
OS	3510	Organizational Behavior and Naval Intelligence .....(4-0)
OS/GV	4207	Special Topics in the Analysis of Intelligence Problems (Option) (4-0)

PROFESSIONAL DEVELOPMENT SEQUENCE

The professional development sequence has as its objective to provide intelligence officers with opportunities for professional growth as naval officers, development of communication skills, and insight into the challenges which presently face the community.

EN	2020	Reasoning and Research Writing ....(0-3)
EN	2030	Writing Seminar .....(0-2)
SP	2020	Communications Models for Staff Briefing .....(0-2)
HG	3001	Human Resource Management .....(2-2)
GV	0010	Seminar in Naval Intelligence (every quarter except the fourth) ..(0-2)

ELECTRONICS AND COMMUNICATIONS ENGINEERING PROGRAMS

CURRICULA NUMBERS 590, 600, 620/620CG

PETER STEVAN RODER, Commander, U. S. Navy, Curricular Officer; B.S., U. S. Naval Academy, 1958; B.S. in Communications Engineering, Naval Postgraduate School, 1965.

ABRAHAM SHEINGOLD, Academic Associate for Electronics/Communications Engineering; B.S., College of the City of New York, 1936; M.S., 1937.

NORMAN FLOYD SCHNEIDEWIND, Academic Associate for Information Systems (Telecommunications); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (Engr.), 1970; D.B.A., 1966.

EUGENE DEXTER NEWTON, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer; B.S. Univ. of Washington, 1961; M.S. in Communications Engineering, Naval Postgraduate School, 1969.

OBJECTIVE—The Electronics and Communications Engineering Programs include curricula designed to satisfy the needs of the service and the interests of the officers in these fields. Successful completion of a curriculum leads to the award of the degree of Master of Science or a higher degree in the principal field. This education permits the officer to more knowledgeably address current and future military problems associated with electronic/communications systems, and expands his base of professional knowledge and technical competence in his subspecialty area. It is designed to enhance performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions.

Within the broad field of electronics/communications engineering, various optional areas may be studied toward the attainment of a degree in electrical engineering. In the field of Information Systems (Telecommunications) unique Navy and Coast Guard Programs of study lead to the attainment of a degree in management. All curricula provide the officer with a well-rounded comprehension of the scientific principles and technical practices in the field of study, and in the process develop a general analytical ability for practical problem solving and a broadened capacity for creative thought. The curricula provide latitude for studies in associated areas outside the field of specialization to accommodate the academic background and individual interests of the officer and help him acquire diverse professional knowledge, a new appreciation for continuing education, an added awareness of the many complex elements of problems, and a new personal confidence that leads to productive achievement throughout his naval career.

ENGINEERING ELECTRONICS CURRICULUM CURRICULUM NUMBER 590

OBJECTIVE (SPECIFIC)—To provide officers, through graduate education, with comprehensive scientific and technical knowledge in the field of electronics as applied to Navy systems. Naval officers who successfully complete this curriculum will be awarded an appropriate subspecialty billet code.

COMMUNICATIONS ENGINEERING CURRICULUM CURRICULUM NUMBER 600

OBJECTIVE (SPECIFIC)—To provide officers, through graduate education, with a comprehensive scientific and technical knowledge in the field of communications engineering as applied to Navy and Defense Command and Control Systems. Naval officers who successfully complete this curriculum will be awarded an appropriate subspecialty billet code.

ELECTRONICS AND COMMUNICATIONS ENGINEERING CURRICULA CURRICULA NUMBERS 590 AND 600

QUALIFICATIONS FOR ADMISSION—Prior Baccalaureate Degree including a background and above average grades in differential/integral calculus and general physics. Those lacking this background may matriculate via the Engineering Science Program.

DESCRIPTION—These curricula are designed to establish a broad background of basic engineering knowledge leading to selected advanced studies in electronic systems, communications, electronic warfare, ships or weapons control, information processing or other pertinent areas of professional applicability. Classes convene semiannually, in March and September.

The standard program leads to the degree of Master of Science in Electrical Engineering. The graduate-studies portion of the program is typically of twelve-months duration. It is preceded by an introductory core program which is designed to provide a smooth transition from previous studies. For entering students who have a non-engineering background, except as stated in the qualifications above, and who are presumed to have been absent from academic studies for four to six years, the background studies may be of up to five quarters duration, leading to a complete program duration of twenty-seven months. For students with better entrance qualifications, special review courses and course validations enable them to complete the introductory core in a lesser time.

Towards the end of their preparatory program, officers are evaluated for academic progress and potential to complete the advanced degree portion of the curriculum. Those officers who have demonstrated a capability to satisfy academic requirements for the Master of Science degree will continue in the master's program and select an appropriate area of subject specialization and thesis research. Academically superior students may be selected, subject to approval of the parent service, for further advanced studies leading to the degree of Electrical Engineer or Ph.D. (with major in electrical engineering). Those officers who are unable to continue in graduate-level studies will pursue a two-quarter terminal program beyond the basic core and, with a typical complete program duration of seven quarters, receive the degree of B.S. in Electrical Engineering, provided that academic requirements are satisfied.

Introductory Core

This portion of the program provides a sound academic background in mathematics, computer

science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. Validation by examination is also encouraged. The courses which are not validated will be programmed using a nominal course load of 16 credit hours per quarter.

Mathematics

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
MA 2121	Differential Equations	4-0
MA 2172	Complex Variables	4-0

Physics

PH 1041	Review of Mechanics and Electricity and Magnetism	5-1
PH 2241	Wave Phenomena	4-2
PH 2641	Atomic Physics	4-2

Circuits and Systems

EE 2101	Basic Circuit Theory	3-2
EE 2102	Circuit Analysis	4-2
EE 2103	Linear Systems Analysis	4-2
EE 2411	Control Systems	3-3

Electronics

EE 2211	Electronics Engineering Fundamentals I	4-2
EE 2212	Electronics Engineering Fundamentals II	4-3
EE 2216	Pulse and Digital Circuits	4-3

Computers

CS 2100	Introduction to Computers and FORTRAN Programming	4-0
EE 2810	Digital Machines	3-3

Electromagnetics

EE 2621	Introduction to Fields and Waves	4-0
EE 2622	Electromagnetic Engineering	3-1

Communications

EE 2114	Communication Theory I	4-0
EE 2217	Communications Circuits	4-3

Graduate Study

The advanced studies program leading to a master's degree is individually designed to be academically sound, consistent with the needs of the service and responsive to the interests and objectives of the officer. The program consists of courses in required subject areas, elective courses in coherent and relevant option areas and thesis research. The degree requirements include the completion of 40 credit hours of approved graduate study. The additional thesis research normally occupies the time equivalent of four courses, allocated during the final three quarters of the program. Any transfer of graduate credit which is applicable may be used to reduce the number of programmed courses.

The Graduate Core

To provide a well rounded graduate program, all students are required to include courses in the subject areas of advanced electronics, signal processing, stochastic processes and advanced systems. Representative courses include the following:

PS 3411	Applied Probability Theory I	4-1
EE 3215	Microwave Devices	4-2
EE 4121	Advanced Network Theory I	3-2
EE 4571	Statistical Communication Theory	3-2
EE 3631	Antenna Engineering	4-2
EE 4433	Advanced Radar Systems	3-2
EE 4461	Advanced Systems Engineering	3-1

Option Electives

The graduate program also includes a course sequence in a selected area. Listed below are representative electives associated with particular areas of professional applicability. Considerable latitude is permitted in specific elective selections, with the choices approved on the basis of consistency of the overall program with professional applicability and an agreement with academic requirements.

Representative Electives

Communications (600 Program)

EE 3422	Modern Communications	3-2
EE 4541	Discrete Signal Processing	3-1
EE 4581	Information and Detection Theory	3-2
EE 4591	Communication Satellite Systems Engineering	3-0

Ship Control

EE 3311	Energy Conversion	3-2
EE 3312	Electromagnetic Machines	3-4
EE 4418	Ship Control Systems	3-2
EE 4412	Nonlinear and Discrete Systems	3-3

Weapons Control

EE 3822	Engineering Applications of Computers	3-3
EE 4417	Optimal Control	4-0
EE 4412	Nonlinear and Discrete Systems	3-3
EE 4473	Missile Guidance Systems	3-1

Electronic Warfare

EE 4481	Electronic Warfare Techniques and Systems	3-3
EE 4482	Signals Intelligence (SIGINT) Systems Engineering	2-2
EE 4473	Missile Guidance Systems	3-1
EE 3641	Electromagnetic Compatibility	3-1

Information Processing

EE 4581	Information and Detection Theory	3-2
EE 4541	Discrete Signal Processing	3-1
EE 3420	Engineering Fundamentals of Electro-Optics	3-1
EE 3822	Engineering Applications of Computers	3-3

Data Systems Engineering

EE 3812	Switching Theory & Logic Design	3-2
EE 3822	Engineering Applications of Computers	3-3
EE 4823	Advanced Digital Computer Systems	3-1
CS 4202	Interactive Computation Systems	3-2

Advanced Electronics

PH 3741	Electronic Properties of Metal and Semiconductors	4-2
EE 4264	Solid State Electronic Devices	3-2
EE 3262	Integrated Electronics	3-3
EE 3652	Microwave Circuits and Measurements	3-2

Bioengineering

EE 3801	Human Physiology	5-0
EE 3820	Bioelectronic Instrumentation	3-3
OA 4680	Human Performance Evaluation	4-0
EE 4890	Computer Modeling of Biological Systems	2-4

Microwave Engineering

EE 3622	Electromagnetic Theory	3-1
EE 3671	Propagation	3-0
EE 4631	Antenna Theory and Applications	3-2
EE 3641	Electromagnetic Compatibility	3-1

Available under any of the above options:

OS 3202	Methods of Operations Analysis/ Systems Analysis	4-0
OS 3204	Defense Resource Analysis	4-0
SM 3301	Introduction to Systems Acquisition	4-0
PS 3412	Applied Probability Theory II	4-0

ELECTRICAL ENGINEER

As determined by superior academic achievement, officers may matriculate into a program leading to the advanced degree Electrical Engineer. This advanced graduate program requires seven quarters of work beyond the Introductory Core. The scope of study is greatly increased over the Master of Science curriculum and a thesis of greater depth is required. In addition, the officer is provided an opportunity for an industrial experience tour of up to 12 weeks duration.

INFORMATION SYSTEMS (TELECOMMUNICATIONS) CURRICULUM CURRICULUM NUMBER 620 AND 620CG

OBJECTIVE (SPECIFIC)—To provide instruction to officers who will perform as Communications Managers of new communications systems applications or as Communications Officers in large commands and staffs, afloat and ashore, including the organization of the Joint Chiefs of Staff and the Defense Communications Agency. Upon successful completion of the curriculum, naval officers will be awarded an appropriate subspecialty billet code.

QUALIFICATIONS FOR ADMISSION—Admission to the curricula requires a Baccalaureate Degree with average grades. Completion of mathematics through college algebra and trigonometry is required for the 620 curriculum. The student must be ready to start calculus courses on enrollment. The qualifications for the 620CG curriculum are the same as the 590 and 600 curricula.

DESCRIPTION—The 620 and 620CG curricula are sponsored respectively by the Naval Telecommunications Command and the U. S. Coast Guard Headquarters. Each curriculum provides comprehensive study in management, with emphasis upon the systems management field. Additionally, the curricula provide study in the technical field appropriate to decision making in advanced system and program management. These technical courses within the 620 curriculum have been especially prepared for non-engineers whereas those in the 620CG curriculum are engineering courses. Classroom instruction is supplemented by guest lecturer seminars which afford the student an opportunity to hear discussions of communications topics by senior military officers and civilians from the Naval Telecommunications Command, Defense Communications Agency and the National Security Agency.

The 620 classes convene in March and September, and the 620CG classes in September. Each student's prior academic transcript will be evaluated for validation of courses or for transfer of credit to cover as many courses as possible. Validation or credit by examination is encouraged for courses whose content has been acquired by experience or service courses.

620 (NAVY) CURRICULUM

Quantitative. Provides the quantitative tools necessary for analyzing problems in information systems (telecommunications) management and for conducting thesis research.

MA 2300	Mathematics for Management	5-0
MA 2040	Matrix Algebra	2-0
PS 3000	Probability and Statistics for Naval Intelligence and Communications Management	4-0
CM 3210	Operations Research for Communications Managers	4-0

Electronics. Provides a non-engineering approach to communications systems. Courses are designed to give the prospective manager sufficient knowledge to be able to discuss and understand communications technology, communications systems, signal transmission systems and systems analysis.

EE 2421	Introduction to Communications Technology	4-2
EE 2422	Communications Systems I	4-3
EE 2423	Communications Systems II	4-3
EE 2424	Signal Transmission Systems	4-2
EE 3425	Communications Systems Analysis	3-3

Financial Management and Economic Analysis. Provides the accounting and economic analysis aspects of military resource allocation problems.

MN 3155	Financial and Managerial Accounting	4-0
MN 3143	Managerial Economics	4-0
MN 3170	Defense Resource Allocation	4-0

Behavioral Science. Provides material on individual and group behavior and social problems in the military. The student is acquainted with contemporary problems of race relations in the military establishment.

MN 2106	Individual and Group Behavior	4-0
HG 3002	Human Resource Development	2-4

Organization and Management. Provides organizational aspects of the DOD telecommunications establishment, DOD procurement policies and management planning and control.

MN 3105	Organization and Management	4-0
MN 3371	Procurement and Contract Administration	4-0
CO 2111	Defense Communications Organization and Planning	3-2
CO 3112	Integrated Defense Telecommunications Systems	3-2

Information Systems. Provides an overview of computer hardware and software concepts and the computer-controlled aspects of message and data communications systems.

CS 2103	Introduction to Computers and COBOL Programming	4-0
CM 3184	Real time Information Systems	4-0
CM 4184	Real Time Information Systems Management	4-0

Electives. Provides the student with an opportunity to pursue his own area of special interest.

MN 4105	Management Policy	4-0
MN 3121	Leadership and Group Behavior	4-0
MN 3161	Managerial Accounting	4-0
MN 4133	Economics of Computers	4-0
CT 4185	Computer-Based Management Information Systems	4-0

Thesis. The student has the opportunity to apply the course material to a practical military telecommunications problem during the last two quarters of the program.

620CG (COAST GUARD) CURRICULUM

Quantitative. Provides the quantitative tools necessary for analyzing communications management and engineering problems.

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
MA 2121	Differential Equations	4-0
MA 2172	Complex Variables	4-0
PS 3411	Applied Probability Theory I	4-1
OS 3203	Survey of Operations Analysis/ Systems Analysis	4-0
OA 4633	Networks Flows and Graphs	4-0

Electronics. Provides extensive coverage of electronics and communications engineering.

EE 2101	Basic Circuit Theory	3-2
EE 2102	Circuit Analysis	4-2
EE 2211	Electronic Engineering Fundamentals I	4-2
EE 2103	Linear Systems Analysis	4-2
EE 2114	Communications Theory I	4-0
EE 2212	Electronic Engineering Fundamentals II	4-3
EE 2621	Introduction to Fields and Waves	4-0
EE 2622	Electromagnetic Engineering	3-1
EE 3422	Modern Communications	3-2
EE 3631	Antenna Engineering	4-2
EE 4571	Statistical Communication Theory	3-2

Financial Management and Economic Analysis. Provides the accounting and economic analysis aspects of military resource allocation problems.

MN 3155	Financial and Managerial Accounting	4-0
MN 3143	Managerial Economics	4-0
MN 3170	Defense Resource Allocation	4-0

Organization and Management. Provides the behavioral, procurement and management planning and control aspects of military communications.

MN 2106	Individual and Group Behavior	4-0
MN 3105	Organization and Management	4-0
MN 3371	Procurement and Contract Administration	4-0

Information and Computer Systems. Provides computer hardware and software design concepts and the computer-controlled aspects of message and data communication systems.

CS 2100	Introduction to Computers and FORTRAN Programming	4-0
CS 3200	Structure of Digital Computers	4-0
CM 3184	Real Time Information Systems	4-0
CM 4184	Real Time Information Systems Management	4-0
CT 4185	Computer Based Management Information Systems	4-0

Electives. Provides the student with an opportunity to pursue his own area of special interest. Representative electives are:

MN 4105	Management Policy	4-0
MN 3121	Group and Organizational Behavior	4-0
MN 3161	Managerial Accounting	4-0
MN 4133	Economics of Computers	4-0

Thesis. The student has the opportunity to apply the course material to a practical Coast Guard telecommunications problem during the last two quarters of the program.

ENVIRONMENTAL SCIENCES PROGRAMS

CURRICULA NUMBERS 372 AND 440

LEROY ROBERT BECHELMAYR, Commander, U. S. Navy; Curricular Officer; B.S., U. S. Naval Academy, 1955; M.S. in Aerology, Naval Postgraduate School, 1957.

CHARLES LUTHER TAYLOR, Academic Associate (Meteorology); B.S., Pennsylvania State Univ., 1942; M.S., 1947.

JOSEPH JOHN VON SCHWIND, Academic Associate (Oceanography); B.S., Univ. of Wisconsin, 1952; M.S. Univ. of Utah, 1960; Ph.D., Texas A&M Univ. 1968.

DAVID CROSBY HONHART, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer, B.S., U.S. Naval Academy, 1963; M.S., Naval Postgraduate School, 1968.

METEOROLOGY CURRICULUM CURRICULUM NUMBER 372 (GROUPS XM, XS)

OBJECTIVE—To provide naval officers with a sound understanding of the science of meteorology and to develop the technical expertise to provide, and utilize, meteorological and oceanographic data in support of all aspects of fleet operations.

Officers who successfully complete this curriculum will be awarded an appropriate subspecialty billet code. However, this education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions. Naval officers will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their naval career.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation.

DESCRIPTION—The Meteorology Curriculum is interdisciplinary in nature and encompasses those areas of meteorology and oceanography which are directly related to environmental support of fleet operations. The program consists of preparatory subjects, a sequence in synoptic and numerical meteorology, a sequence of courses in dynamic meteorological processes and a sequence of oceanography courses which is unique in any such offering. The program recognizes the interaction of the atmosphere and the ocean mass and deals with their relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, computer solutions to problems, and guest lectures and seminars. Upon completion of the program, the student is qualified to serve independently as a meteorological and oceanographic forecaster. By completing a required thesis, he is introduced to the problems associated with independent research. Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology.

Matriculation occurs in March and September of each year. Although the program is designed for eight academic quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

Preparatory Courses: provides the academic tools necessary for successful pursuit of the remaining courses.

MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MA 3132	Partial Differential Equations & Integral Transforms	4-0
MA 3232	Numerical Analysis	3-2
MA 3243	Numerical Methods for Partial Differential Equations	4-1
MR 2200	Introduction to Meteorology	4-0
MR 2420	Principles of Measurement	3-2
MR 2520	Climatology and Statistics	3-1
OC 2120	Survey of Oceanography	4-0

Synoptic and Numerical Meteorology Sequence:

MR 2205	Introduction to Meteorological Analysis	0-4
MR 3520	Advanced Climatology	3-1
MR 3220	Meteorological Analysis	3-0
MR 3225	Meteorological Analysis Laboratory	0-6
MR 3230	Tropospheric and Stratospheric Meteorology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-9
MR 3250	Tropical Meteorology	3-0
MR 3255	Tropical Meteorology Laboratory	0-6
MR 3260	Prognostic Charts and Extended Forecasting	3-0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0-6
MR 3279	Case Studies in Environmental Support	0-4
MR 4323	Numerical Weather Prediction	4-3

Dynamic Meteorology Sequence:

MR 3420	Geophysical Thermodynamics	4-0
MR 4321	Introductory Geophysical Fluid Dynamics	4-0
MR 4412	Heat Transfer Processes	4-0
MR 4322	Dynamic Meteorology	4-0
MR 4413	Air/Sea Interaction	4-0
MR 3421	Cloud Physics and Atmospheric Pollution	3-1

Oceanography Sequence:

OC 3260	Sound in the Ocean	3-0
OC 3617	Acoustical Forecasting for Meteorologists	2-2
OC 3611	Ocean Wave and Surf Forecasting	2-0
OC 3615	Ocean Wave and Surf Forecasting Laboratory	0-4

Thesis Preparation: Ample time is provided for the student to complete research for a thesis in the area of his primary interest. Two elective courses are also available to further his knowledge in the science or its related fields.

OCEANOGRAPHY CURRICULUM
CURRICULUM NUMBER 440
(GROUPS OM, OS)

OBJECTIVE—To provide naval officers with a sound understanding of the science of physical oceanography and to develop the technical expertise to provide, and utilize, oceanographic data in support of all aspects of fleet operations. Particular emphasis is placed on the understanding of oceanographic environmental effects on the solution of the Antisubmarine Warfare problems.

Officers who successfully complete this curriculum will be awarded an appropriate subspecialty billet code. However, this education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions. Naval officers will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their naval career.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry is considered to be minimal preparation.

DESCRIPTION—The Oceanography Curriculum is interdisciplinary in nature and encompasses a broad spectrum of oceanography which is directly related to oceanographic support of fleet operations. The program consists of broad technical background material, classical oceanography courses which satisfy degree requirements and additional course work specifically designed to prepare a naval officer for oceanographic duties with the fleet. The program is unique in that a considerable effort is made to relate a thorough knowledge of the physical ocean to the solution of fleet problems involving the ocean environment.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA is available for class laboratory experience as well as for individual research efforts. Guest lecturers, seminars, and in situ study at the Naval Arctic Research Laboratory in Barrow, Alaska, serve to round out the program. Upon completion of the program, the student is qualified to serve in any of the several oceanography billets in the Navy. By completing a required thesis, he is introduced to the problems associated with independent research. Successful completion of the program leads to the awarding of the degree of Master of Science in Oceanography.

Matriculation occurs in March and September of each year. Although the program is designed for eight quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

Preparatory Courses and Broad Technical Background Material: provides the academic tools necessary for successful pursuit of the remaining courses.

OC 2120	Survey of Oceanography	4-0
MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MA 3132	Partial Differential Equations & Integral Transforms	4-0
MA 3232	Numerical Analysis	3-2
EE 2112	Electrical Circuits, Devices & Systems	3-2
OC 3150	Geophysical Random Processes	4-2
MR 2210	Marine Meteorology for Oceanographers	4-3
OC 4413	Sea-Air Interaction	3-0

Degree Requirement Courses:

OC 3420	Biological Oceanography	3-3
OC 3320	Geological Oceanography	3-3
OC 3520	Chemical Oceanography	3-3
OC 3221	Descriptive Physical Oceanography	4-0
OC 4321	Introductory Geophysical Fluid Dynamics	4-0
OC 4322	Ocean Dynamics	4-0
OC 4211	Waves and Tides	4-0
OC 4213	Coastal Oceanography	3-2
OC 3709	Scientific Cruise Experience	0-4
OC 4900	Seminar in Oceanography	2-0

Additional Courses to Satisfy Fleet Requirements:

PH 3431	Physics of Sound in the Ocean	4-2
OC 4260	Sound in the Ocean & Acoustic Models	4-0
EE 3112	Electronic Oceanographic Systems & Processors	4-2
OC 3321	Marine Geophysics	3-0
OC 4612	Polar Oceanography	3-2
OC 3901	Basic Hydrography	3-2
OC 3620	Acoustical Forecasting	3-4
OC 3610	Ocean Wave Forecasting	2-2

Thesis Preparation: Ample time is provided for the student to complete research for a thesis in the area of his primary interest. Four elective courses are also available to further his knowledge in the science or its related fields.

NAVAL ENGINEERING AND ENGINEERING SCIENCE PROGRAMS

CURRICULA NUMBERS 570 AND 460

PHILIP FURST CAROTHERS, JR., Captain, U. S. Navy; Curricular Officer; B.S.M.E., Pennsylvania State Univ., 1952; M.S.M.E., Naval Postgraduate School, 1961.

PAUL FRANCIS PUCCI, Academic Associate for Naval Engineering; B.S.M.E., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

SAMUEL DELL MCLEOD, JR., Lieutenant Commander, U. S. Navy; Assistant Curricular Officer for Engineering Science; B.S. with major in Computer Science, Naval Postgraduate School, 1972.

CRAIG COMSTOCK, Academic Associate for Engineering Science; B.P.E., Cornell Univ., 1956; M.S., Naval Postgraduate School, 1961; Ph.D., Harvard Univ., 1965.

NOTE *The Naval Engineering and Engineering Science curricula are administered from the same Curricular Office solely for organizational reasons and will be treated separately in the following paragraphs.*

NAVAL ENGINEERING CURRICULUM CURRICULUM NUMBER 570

Directly administered by Captain Philip F. Carothers, USN, and Professor Paul F. Pucci.

OBJECTIVE—to provide selected naval officers, irrespective of designator, advanced education using the particularly appropriate vehicles of the disciplines of mechanical engineering and management to develop the capability for independent and creative problem solving in the entire spectrum of future duty assignments. This education enhances performance throughout their career in all duty assignments, including operational billets, technical management assignments and upper management policy making positions. Officers develop sound graduate level technical ability based on engineering and scientific principles, develop analytic ability for practical problem solving and increase their confidence in themselves so that their performance is enhanced throughout their careers.

QUALIFICATIONS FOR ADMISSION—To qualify for admission to the Naval Engineering Program, a baccalaureate degree with above average grades in mathematics, physical sciences, and engineering is required. Completion of mathematics through integral calculus, engineering physics, and chemistry is considered to be minimal preparation for these programs. Courses in statics, dynamics, fluid mechanics, thermodynamics, electric fields, electric circuits, and electronics are desirable. Students lacking these quantitative prerequisites will be accepted in certain cases, where their academic records indicate that they are exceptional students and there are indications that they can succeed in technical studies.

DESCRIPTION—The Naval Enginering Program offers courses in mechanical engineering and management which are oriented toward the particular application of these disciplines to the operation and maintenance of modern sophisticated warships and weapons systems at sea and to the demanding business of the Navy ashore in designing, developing, building and maintaining these ships and weapons systems. Classes convene semiannually, in March and September. The program is divided into introductory study and graduate study portions. The introductory study portion is designed to bring all students up to a common level before entry into the graduate level study portion of the program. The length of the introductory study portion can vary from zero up to six quarters depending upon the student's background, prior academic preparation and length of time away from academic work. The length of the graduate study program varies from one up to three quarters for the Master of Science in Mechanical Engineering and from one up to six quarters for the Engineer Degree or the Dual Masters degrees in Mechanical Engineering and in Management. The Doctor of Philosophy, which is available to a limited number of officers who demonstrate superior academic performance, normally requires about two years of studies after the student qualifies for award of the Master of Science and is limited to a total program not to exceed four years in residence.

Near the end of the introductory phase of the program, officers are screened for admission to the graduate study programs. Criteria for selection include academic performance, individual preference and tour availability. Those officers who are not admitted to candidacy are graduated one quarter later and, if qualified, are awarded the degree of Bachelor of Science in Mechanical Engineering. Those officers who are admitted to candidacy in the master's degree program elect an option course sequence and submit an acceptable thesis on a subject approved by the Department of Mechanical Engineering in order to qualify for the degree Master of Science in Mechanical Engineering.

Officers requesting admission to the dual master's program are selected at the end of the introductory study program, whereas officers requesting admission to the engineer's degree program are selected after the first quarter of studies in the master's degree program. Criteria for selection for admission to these programs include superior academic performance, tour availability and demonstrated capability to perform in the environment of the professional engineer. Preliminary screening of candidates for these programs is accomplished at the Postgraduate School, final approval for admission to the program is accomplished by request to the Chief of Naval Education and Training (CNET). Requests for admission to the Ph.D. Program are made about one quarter before all of the requirements for award of the Master of Science have been completed.

Upon successful completion of one of the approved Naval Engineering programs, naval officers will be awarded an appropriate subspecialty billet code.

Introductory Study

This portion of the program provides the necessary background for successful pursuit of the graduate curricula. Each student's prior academic transcripts will be evaluated for validation of as many of the introductory

study courses as possible. Validation of courses, including graduate level courses, by examination is encouraged. The courses not validated will be programmed for study using a normal course load of 17 credit hours per quarter.

Mathematics

MA 1100	Calculus Review	4-0
MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MA 2232	Numerical Methods	3-1
MA 3132	Partial Differential Equations and Integral Transforms	4-0

Engineering Mechanics

ME 2501	Statics	3-0
ME 2502	Dynamics	4-0
ME 2201	Fluid Mechanics	4-2
ME 2610	Mechanics of Solids I	3-2
ME 3201	Principles of Fluid Dynamics	3-1
ME 3440	Engineering Systems Analysis	4-0
ME 3521	Mechanical Vibrations	3-2
ME 3611	Mechanics of Solids II	4-0
ME 3711	Design of Machine Elements	3-2

Thermodynamics and Heat Transfer

ME 2101	Engineering Thermodynamics	4-0
ME 3150	Heat Transfer	4-2
ME 3450	Thermodynamics of Marine Power Systems	3-2
ME 3301	Nuclear Power Systems	5-0

Materials Science

MS 2201	Engineering Materials	3-2

Electrical Engineering

EE 2104	Electrical Engineering Fundamentals for Mechanical Engineers I	3-2
EE 2105	Electrical Engineering Fundamentals for Mechanical Engineers II	4-2
EE 3314	Distribution and Conversion of Electrical Energy	3-2

Mechanical Engineering Lab

ME 2410	Mechanical Engineering Lab I	2-3
ME 3430	Mechanical Engineering Lab II	1-3

Management

*MN3xxx	Financial Management for Naval Engineers	4-0

*Revised course under development at time of catalogue submission.

Graduate Study

The graduate programs consist of required courses, elective (option) courses and thesis research. For the Master of Science in Mechanical Engineering, students must complete the required course OS 3206—Operations Research for Mechanical Engineers (4-0), an acceptable thesis, one elective course in a subject outside the Department of Mechanical Engineering and six elective courses from the elective "packages" shown below:

Fluid Mechanics Options

ME 3202	Gas Dynamics	3-1
ME 3801	Fluid Power Control	3-2
ME 4211	Hydrodynamics	4-0
ME 4220	Viscous Flow	4-0
ME 4240	Advanced Hydrodynamics	4-0

Heat Transfer Options

ME 4161	Conduction & Radiation Heat Transfer	4-0
ME 4162	Convection Heat Transfer	4-0
ME 4230	Advanced Topics in Fluid Dynamics and Heat Transfer	4-0

Reactor Engineering Options

ME 4311	Nuclear Reactor Analysis I	4-0
ME 4312	Nuclear Reactor Analysis II	4-0
ME 4321	Reactor Engineering Design	4-2

Engineering Mechanics Options

ME 3712	Design of Machinery	2-4
ME 4512	Advanced Dynamics	4-0
ME 4522	Advanced Vibrations	4-0
ME 4612	Advanced Mechanics of Solids	4-0
ME 4613	Finite Element Methods	4-0
ME 4620	Theory of Continuous Media	4-0

Materials Science Options

MS 3202	Properties, Problems & Failures of Structural Materials	3-2
MS 3304	Corrosion	3-2
MS 4811	Mechanical Behavior of Engineering Materials	3-2

Candidates for the degree Mechanical Engineer, will satisfy the course requirements for the Master of Science in Mechanical Engineering and will complete the following additional requirements:

a. Six elective courses from the elective "packages" shown for the Master's degree (for a total of twelve).

Two elective courses outside the department of Mechanical Engineering (for a total of three).

c. One elective in any department.

An acceptable thesis is required for the degree Mechanical Engineer; however, this thesis will also fulfill the requirements for the Master of Science and both degrees will normally be awarded to qualified candidates.

Students admitted to the dual master's program in Naval Engineering will fulfill the requirements for both the Master of Science in Mechanical Engineering and the Master of Science in Management. The thesis requirements for these degrees may be met by the submission of one thesis, provided that it is acceptable to both the Department of Mechanical Engineering and to the Department of Operations Research and Administrative Sciences. Candidates for the dual master's degrees in Naval Engineering may obtain the Master of Science in Management in either Financial Management or Systems Acquisition Management. The programs in management which are followed by Naval Engineering students are similar to those shown for the Financial Management Curriculum (817) and the Systems Acquisition Management Curriculum (816) which are shown in the section of the catalogue describing those curricula, however, students in the Naval Engineering Program who are accepted into the dual master's program will normally complete the requirements for both degrees in a program which does not exceed a total of twelve quarters.

ENGINEERING SCIENCE CURRICULUM
CURRICULUM NUMBER 460

Directly administered by LCDR Samuel D. McLeod, Jr., USN, and Professor Craig Comstock.

OBJECTIVE—To provide officer students who lack sufficient or reasonably current preparation in mathematics and physical sciences an opportunity

to qualify for admission into a graduate level technical program.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree and successful completion of at least one college mathematics course in algebra or trigonometry is required.

DESCRIPTION—There are two inputs to the Engineering Science curriculum annually; i.,e., March and September. Officers may be ordered to a postgraduate curriculum via Engineering Science, or they may be ordered directly to Engineering Science and given an option of transferring to an appropriate quantitative curriculum after completion of two quarters in the program, dependent upon available quotas and the officer's academic performance. Where warranted, those students who do not qualify in two quarters for transfer to a graduate level curriculum may be extended an additional two quarters.

During their first quarter on board, Engineering Science students are briefed by Curricular Officers of appropriate graduate level programs and made aware of curricula available to them.

Neither academic degrees nor subspecialty billet codes are awarded by the Engineering Science curriculum.

Conducting tension tests at the Naval Postgraduate School's mechanical engineering laboratory are LT Donald B. Davis (seated) and LT Lawrence J. Opezio, both of the Coast Guard. An important part of the mission of the School is to foster research as a means of offering stimulating educational opportunities to students.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS PROGRAM
CURRICULUM NUMBER 360

JOSEPH HENRY CYR, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S. Purdue Univ., 1960; M.S., Naval Postgraduate School, 1969.

JAMES KERN HARTMAN, Academic Associate; B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

MICHAEL CHARLES WATERS, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer; B.S. Oregon State Univ., 1963; M.S. Naval Postgraduate School, 1971.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM CURRICULUM NUMBER 360 (Group RO)

OBJECTIVE—To develop judgment and professional expertise in scientific methods of application to the quantitative analysis of military operational and defense managerial problems ashore and afloat. The disciplines of mathematics, probability, statistics, economics, human factors, physical science, and optimization supply the theoretical background for analyzing alternative choices in tactical and strategic warfare and in planning, budgeting and procurement of systems and forces. Skills in finding relevant information, generating decision criteria, and selecting alternatives are developed as well as computational capability.

This education enhances performance in all duties throughout a naval career, including operational billets, technical management assignments and policy making positions.

As a result of completing the program, officers develop sound graduate level technical ability based on scientific and mathematical principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their military careers.

QUALIFICATIONS FOR ADMISSION—A baccalaureate degree with above-average grades in mathematics is required. Completion of mathematics through calculus is considered minimal preparation. A one year course in college physics is highly desired (Supply Officers excluded). Students lacking these quantitative prerequisites will be accepted, in certain cases, where their under-graduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative subjects, and outstanding motivation for the program.

DESCRIPTION—The Operations Research/Systems Analysis program is interdisciplinary in nature, consisting of course work in operations research, probability and statistics, mathematics, physical science, economics, human engineering, and computer science. Classes convene semiannually, in March and September. As the typical officer student is returning to a formal academic program after 6 or 7 years (average) of operational military duty, and because the needs of the military services frequently require that the officer's graduate work lie in a field different from his undergraduate major, the program includes a certain amount of introductory material which must precede advanced study in this field.

The advanced study phase of the program will normally require four to five academic quarters to complete. The introductory phase of the program will vary in length from one to four academic quarters, depending upon the student's background and academic preparation. Credits transferred from other institutions may be applied to graduate degree requirement. Validation of courses is highly encouraged.

Near the end of the introductory phase of the program, officers are screened for admission to master's candidacy. Selection is based on the student's demonstrated academic performance and potential. Those officers not selected to master's candidacy are terminated one quarter later, and, may be awarded the degree of Bachelor of Science in Operations Research. Those officers admitted to the Master's candidacy elect an option course sequence and must submit an acceptable thesis on a subject previously approved by the Department of Operations Research and Administrative Sciences in order to qualify for the degree Master of Science in Operations Research.

An integral part of the advanced phase of the program is a six-week experience tour in which the officers are assigned as working members of appropriate military or industrial groups engaged in operations research/systems analysis or military problems. The experience tour is designed to permit the student to become involved in the practical application of military operations research and to identify problems of real military interest which the officer may pursue as part of his advanced study and thesis effort.

An important adjunct to the formal classroom work is the seminar series, OA 0001 (0-2), in which guest lecturers present first-hand information as to practical principles and techniques in the field of Operations Research/Systems Analysis. This seminar is scheduled for every Operations Research/Systems Analysis student in every quarter.

Upon successful completion of the program, the naval officer is awarded an appropriate subspecialty billet code.

A few exceptionally well-qualified officers are selected for doctoral studies each year, depending upon the needs of the military services.

Introductory Study

The introductory study portion of the Operations Research/Systems Analysis program provides necessary background and tool subjects for successful pursuit of the graduate study. This portion of the program is of variable length depending on the amount of the course work listed below which can be validated by examination or credited from a prior academic transcript. Descriptions of the course appear in the departmental listings of this catalogue. A nominal course load is 16 credit hours during

any academic quarter. Prior to beginning the program a review of elementary calculus, elementary physics and computer programming, through correspondence or extension courses, is strongly urged.

Mathematics

MA 2109	Topics in Calculus	5-0
MA 2110	Multivariable Calculus	4-0
MA 2042	Linear Algebra	4-0

Probability & Statistics

OA 2301	Probability	4-0
OA 3302	Probability and Statistics	4-0
OA 3303	Statistics	4-1

Physical Science

PH 2121	Applied Physics I	4-0
PH 2122	Applied Physics II	4-0

Economics

OA 3609	Introduction to Mathematical Economics	4-0
OA 3610	Utility Theory and Resource Allocation	4-0

Operations Analysis

OA 2600	History and Nature of Operations Analysis	2-0
CS 2600	Introductory Computing and Computer Science for Operations Analysis	2-0
OA 3604	Linear Programming	4-0
OA 3653	System Simulation	4-0
OA 3657	Human Factors in System Design	4-0

Graduate Study

The graduate program consists of required courses, elective courses, option courses, and experience tour, and thesis research. Any transfer of graduate credit which is applicable may be used to reduce the number of courses taken in the program. The required courses include those subjects which are necessary for in-depth pursuit of any of the option areas, for thesis research, and for the practice of the art of Operations Research on military applications.

Required Courses

OA 3611	Systems Analysis I	4-0
OA 3660	Analysis of Operational Data	3-1
OA 3654	War Gaming	3-2
OA 3704	Stochastic Models I	4-0
OA 4705	Stochastic Models II	3-2
OA 4631	Nonlinear and Dynamic Programming	4-0

ELECTIVE COURSES—Two free elective courses from any discipline may be chosen. Electives which will broaden the student's perspective on military problems are recommended.

EXPERIENCE TOUR—Eight quarter hours are allocated for the experience tour which is usually taken in the last six weeks of the first quarter of advanced study.

THESIS RESEARCH—Twelve quarter hours are allocated for thesis research, four each in the student's final three quarters of the program.

OPTION COURSES—Five courses chosen from a particular option area are required. The options offer a degree of specialization in a particular area in recognition of requirements of the officer's military service or corps. The selection of these courses is developed in consultation with, and approved by, the faculty option coordinator from the following areas:

Systems Analysis Option—Preparation for dealing with defense department resource allocation, planning, and programming.

OA 4613	Theory of Systems Analysis	4-0
OA 4614	Methods and Practice of Systems Analysis	4-0
OA 4615	Econometrics	4-0
OA 4616	Defense Expenditure and Policy Analysis	4-0
MN 3770	Economics of Labor and Industrial Organization	4-0
MN 4920	Public Expenditure Analysis	4-0
OA 4639	Control in Economics	4-0

Operations Evaluation (Navy) Option—Preparation for dealing with the analysis of tactics and hardware in Naval Warfare.

OA 4651	Search Theory and Detection	4-0
OA 4652	OR Problems in Naval Warfare	3-0
OA 4321	Design of Experiments	3-1
OA 4685	Skilled Operator Performance	3-2
OA 4653	Operational Test and Evaluation	3-2
OC 3260	Sound in the Ocean	3-0
OA 4642	Advanced Topics in War Gaming and Simulation	3-2
OA 4662	Reliability and Weapon System Effectiveness Measurement	4-0

Operations Evaluation (Marine Corps, Army) Option—Preparation for dealing with the analysis of land combat operations.

OA 4654	Mathematical Models of Combat	4-0
OA 4655	Optimization of Combat Dynamics	4-0
OA 4321	Design of Experiments	3-1
OA 4680	Human Performance Evaluation	4-0
OA 4634	Games of Strategy	4-0
OA 4662	Reliability and Weapons System Effectiveness Measurement	4-0
HI 3032	History of Recent Insurgency Warfare	4-0
OA 3656	Operations Research Problems in Special Warfare	4-0

Human Factors Option—Preparation for dealing with human performance evaluation and the design of man/machine systems.

OA 3658	Human Factors in System Design II	3-0
OA 4685	Skilled Operator Performance	3-2
OA 4695	OR in Man/Machine Systems	4-0
MN 2106	Industrial and Group Behavior	4-0
MN 3111	Industrial Psychology	4-0
MN 4114	Personnel Performance Evaluation	4-0
MN 4115	Personnel Motivation	4-0

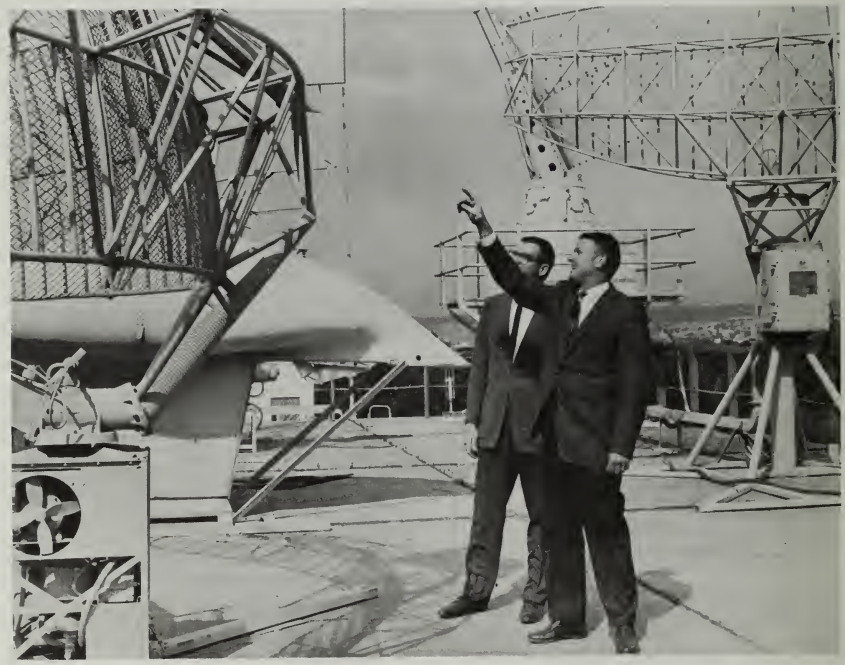
Logistics Option–Preparation for dealing with supply systems for Navy Supply Corps and Quartermaster or Maintenance officers.

OA 3620	Inventory I	4-0
OA 4621	Inventory II	4-0
OA 4622	Seminar in Supply Systems	4-0
MN 2150	Financial Accounting	4-0
MN 3161	Managerial Accounting	4-0
OA 4440	Time Series Analysis	4-0
MN 3371	Procurement and Contract Administration	4-0
MN 4181	Application of Management Information Systems	4-0

Theory and Techniques Option–Preparation for dealing with the theory and techniques of operations research.

OA 4321	Design of Experiments	3-1

OA 4633 Network Flows and Graphs 4-0
OA 4306 Applied Statistics 4-0
OA 4662 Reliability & Weapons Systems Effectiveness Measurement 4-0
OA 4706 Stochastic Models III 4-0
OA 4634 Games of Strategy 4-0
PS 3421 Nonparametric Statistics 4-0
OA 3620 Inventory I 4-0



Part of the equipment used to demonstrate radar technology at the Naval Postgraduate School

WEAPONS ENGINEERING PROGRAMS
CURRICULA NUMBERS 380, 521, 525, 530 and 535

RAYMOND WILLIAM HINE, Commander, U.S. Navy, Curricular Officer; B.S., U. S. Naval Academy, 1955; B.S., Naval Postgraduate School, 1961.

DONALD HUGH SPROUSE, Lieutenant Commander, U.S. Navy, Curricular Officer, Operational Systems Technology (ASW) Program; B.S., U. S. Naval Academy, 1961; M.S. Naval Postgraduate School, 1966.

JOHN NORVELL DYER, Academic Associate; B.A. Univ. of California at Berkeley, 1956; Ph.D., 1960.

SAMUEL MATTHEW CLAWSER, III, Lieutenant, U.S. Navy, Assistant Curricular Officer; B.S. Univ. of Oklahoma, 1966; B.A., 1966; M.S., 1967; Ph.D., 1969.

Several curricular programs are administered by the Weapons Engineering Curricular Office as follows:

Weapon Systems Engineering, Curriculum 530, with options in Electro-optics/Laser Technology, Electrical Engineering, and Weapons Systems Technology.

Operational Systems Technology (ASW), Curriculum 525.

Engineering Acoustics, Curriculum 535.

Nuclear Science, Curriculum 521.

Advanced Science, Curriculum 380, with several options.

Allied officers may enroll in these curricula (with the exception of 525), subject to the exclusion of classified courses as determined by the Chief of Naval Operations.

OBJECTIVE—To provide graduate education to officers in the fundamentals of certain engineering, scientific and analytical principles with which to increase their ability to analyze, understand, and manage the complex naval weapon systems in the environments in which they operate; to enhance operational and command competence of naval officers in various warfare subspecialties; to provide the professional expertise, technical competence and practical experience to develop the ability to relate fundamental concepts directly to naval weapon systems; to build a new appreciation for continuing education; to broaden their capacity for original thought, and to enhance their discovery of a new personal confidence leading to productive achievement throughout their naval career.

This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments and policy making positions, thereby preparing the officer for increased responsibility, including command, both ashore and afloat.

QUALIFICATIONS FOR ADMISSION—Above average grades in mathematics through differential and integral calculus. Courses in the physical sciences and engineering are desirable. The structure of each curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The extent of this preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with his Curricular Officer and Academic Associate.

Officers with less technical background than is considered sufficient for direct entry into one of the programs described here may be first enrolled in the Engineering Science Curriculum for one or more quarters for additional preparation.

For those officers who can devote the time required prior to entrance, a TEMAC course which is a good review of mathematics through calculus is available upon request from the Naval Postgraduate School.

DESCRIPTION—The various curricula described below are generally interdisciplinary in nature because of the wide knowledge required to understand a typical weapon system. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. In a typical program, most of the first four or five quarters are devoted to the basic "core" material. Portions of this undergraduate preparation may be validated by an academically prepared officer to permit study to greater depth or breadth in graduate electives, or subject to course scheduling limitations, to shorten his time on board. The remainder of the program is dedicated to advanced graduate specialization and elective choices. Upon successful completion of an approved curriculum, officers will be awarded an appropriate subspecialty billet code. Officers should refer to the *Annual Naval Officer Billet Summary* which will reflect (subsequent to a mid-1974 revision), a significantly greater variety of billets for weapon subspecialists. Students will be awarded the degree of Master of Science or Bachelor of Science in an appropriate discipline dependent upon academic achievement and successful completion of required courses. Consistent with the needs of the service, the academically superior student may continue studies leading to professional degrees or to the Ph.D. degree. On-going counseling is provided by the Curricular Officer/Academic Associate team for all students and a close professional relationship between fficer students and faculty enables each officer to make his time at the School a valuable asset to his professional development and career.

Descriptions of each curriculum and typical programs ollow. Specific degree requirements may be found under the appropriate departmental section of the catalogue.

WEAPON SYSTEMS ENGINEERING CURRICULUM NUMBER 530

DESCRIPTION—This curriculum encompasses options in Electro-optics/Laser-Technology, Electrical Engineering, and Weapons System Technology. Classes convene in March and September. Subject to service needs, the student may select a program of study leading to the Master of Science degree in either Physics, (electro-optics and laser technology option), or Electrical Engineering, with emphasis on radar and control systems. The Weapon Systems Technology option will lead to the degree Master of Science in Applied Science.

Upon successful completion of the curriculum, naval officers will be awarded an appropriate subspecialty billet code.

Short descriptions of each option within Curriculum 530 follow, along with samples of typical programs. Every effort is made to tailor programs to meet individual needs and service requirements within the availability of course offerings.

ELECTRO-OPTICS/LASER TECHNOLOGY OPTION

DESCRIPTION (SPECIFIC)—This option is directed to a rapidly emerging field of science and technology with many military applications. While those applications relating specifically to naval use are emphasized, the entire spectrum of electro-optic and laser technology is viewed, with emphasis on the concepts of systems applications and utilization. Graduates will be qualified to participate professionally in the development, design, evaluation, operation, integration and management of these complex and important systems which will enhance their potential for command at sea and ashore.

Introductory Study

This portion of the program provides the necessary mathematical, scientific and engineering courses required for successful pursuit of the graduate curriculum. Each student's academic transcript will be evaluated for validation of as many of these courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

Mathematics

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
MA 2121	Differential Equations	4-0
MA 2161	Introduction to Mathematical Physics	5-0
MA 2232	Numerical Methods	3-1
MA 3132	Partial Differential Equations and Integral Transforms	4-0
PS 2315	Data Reduction and Error Analysis	4-0

Science and Engineering

PH 1051	Review of Vector Mechanics and Introduction to Fluids	4-2
PH 2151	Mechanics I	4-0
PH 2152	Mechanics II	4-0
PH 2251	Waves and Particles	4-2
PH 2260	Optical Physics	4-2
PH 2351	Electromagnetism I	4-0
PH 2352	Electromagnetism II	4-0
PH 2551	Thermodynamics	3-0
EE 2104	Electrical Engineering Fundamentals I	3-2
EE 2105	Electrical Engineering Fundamentals II	4-2

Graduate Study

The graduate program consists of required courses, electives, and a thesis. The typical graduate program is four or five quarters in length, depending on previous academic background.

Required courses

PH 3280	Electro-optics	4-2
PH 4281	Electro-optic Devices	4-0
PH 4760	Solid State Physics	4-2
EE 4421	Systems Concepts of Electro-optics	3-1

Elective Courses

A wide variety of elective courses is available. Among those most appropriate and most often selected are the following:

EE 4422	Electro-optic Systems Engineering	3-1
PH 4661	Plasma Physics I	4-0
PH 4662	Plasma Physics II	3-0
PH 4851	Nuclear Physics I	4-2

Appropriate courses offered in the areas of Operational Analysis, Management or other related fields may also be selected.

ELECTRICAL ENGINEERING OPTION (GROUP WE)

DESCRIPTION (SPECIFIC)—This option is directed toward those aspects of electrical engineering (weapons) which are of particular importance to the military officer. The curriculum establishes a broad engineering background leading to graduate studies in electronic systems, communications, electronic warfare, information processing and weapons control. The graduate will be qualified to address knowledgeably current and future military problems associated with electronics/communications/control systems, and will have expanded his base of professional and technical competence.

Introductory Study

This part of the program is identical to the basic core of the Electronics Engineering Curriculum (590).

Graduate Study

To provide a well-rounded graduate program, all students are required to include courses in the subject areas of advanced systems engineering, signal processing, and stochastic processes. Representative courses include the following.

EE 3215	Microwave Devices	4-2
EE 4121	Advanced Network Theory I	3-2
EE 4412	Nonlinear and Discrete Systems	3-3
EE 4417	Optimal Control	4-0
EE 4433	Advanced Radar Systems	3-2
EE 4473	Missile Guidance Systems	3-1
EE 4481	Electronic Warfare Techniques and Systems	3-3
EE 4541	Discrete Signal Processing	3-1
EE 4571	Statistical Communication Theory	3-2
PS 3411	Applied Probability Theory I	4-1

In addition to the above, typical elective courses can be selected from the following.

EE 3631	Antenna Engineering	4-2
EE 3641	Electromagnetic Compatability	3-1
EE 3812	Switching Theory and Logic Design	3-2
EE 3822	Engineering Applications of Computers	3-3
EE 4461	Advanced Systems Engineering	3-1
EE 4823	Advanced Digital Computer Systems	3-1

WEAPON SYSTEMS TECHNOLOGY OPTION

OBJECTIVE (SPECIFIC)—In addition to the objectives stated earlier, this option is designed to educate the officer in the fundamentals of systems engineering so that he will be able to translate operational specifications into systems parameters, to measure system effectiveness and to view components of large systems in proper perspective, and

to provide project-type experience to develop the ability to relate fundamental concepts directly to naval weapon systems, thus significantly enhancing his potential for command billets.

DESCRIPTION (SPECIFIC)—This option, expected to be available by September 1974, is designed to meet a need for greater broad-based education with emphasis in systems engineering concepts. Throughout the curriculum, application and systems engineering techniques will be associated with current naval weapon systems. Since many of the courses in this curriculum have not yet been assigned course numbers and are not listed in the departmental course listings of this catalogue, a typical program is not shown.

This option will contain course offerings relating to computer sciences and real-time computer systems; flight dynamics; materials science; electromagnetic wave propagation and radar; the physics and chemistry of electro-optics and lasers; technology of explosives and propellants; the techniques and methodology of systems engineering; electrical engineering with an emphasis on control systems; and an in-depth option sequence allowing specialization in some technical discipline. Part of the last six months of this program is to be devoted to a related weapon design/evaluation group project or thesis. This will provide an opportunity for the student to apply the systems engineering concepts and broad-based education toward a meaningful and challenging project. Graduates of this primary option of the 530 curriculum will be better prepared to operate and manage the complex combat systems of fleet units as well as manage the development and integration of weapon systems while assigned responsible billets in the shore establishment.

OPERATIONAL SYSTEMS TECHNOLOGY (ASW) CURRICULUM
CURRICULUM NUMBER 525
(GROUP IX)

OBJECTIVE (SPECIFIC)—The objective of this unique interdisciplinary curriculum is to enhance operational and command competence, afloat and ashore, of unrestricted line officers in the Warfare specialties for the subcategory of ASW and the Additional Qualification Designator of ASW Operational and Technical Expert. The curriculum convenes annually in March.

QUALIFICATIONS FOR ADMISSION—Officers selected for this program will have demonstrated outstanding performance and have served in at least one ASW related afloat billet. Academic qualifications are similar to those for the other Weapons Engineering curricula. A typical class is comprised of officers representing each of the ASW communities (surface, subsurface, and aviation).

DESCRIPTION (SPECIFIC)—This is an interdisciplinary technical program which integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science and meteorology. Several group projects are incorporated into the program to further integrate the material presented in lectures and specialized laboratory exercises and to give practice in the systems approach. As a culmination of the program, about half of the student's time in the last six months is devoted to an ASW related group project/thesis, which provides an opportunity to apply the graduate education and the officer's experience with the systems approach to a challenging project.

Naval officers who successfully complete this program are awarded the appropriate subspecialty billet code and receive the degree Master of Sciences in Systems Technology.

Introductory Study

This portion of the program is generally preparatory in nature and some portions of it may be validated by the officer with appropriate operational and academic experience. Because of the integrated nature of the course work in this curriculum, however, validation will be certified only after careful consideration and consultation with the Curricular Officer and Academic Associate.

Mathematics

MA 2129	Elements of Linear Algebra, Ordinary Differential Equations, and Fourier Series	4-0
MA 2181	Vector Calculus (First half of quarter)	2-0
MA 3139	Partial Differential Equations and Transforms for Wave Propagation	4-0
PS 3411	Applied Probability Theory I	4-1
OS 2202	Description Statistics and Operations Research Models (Second half of quarter)	2-0

Computer Science

CS 1500	Introduction to Calculation and Programming (First half of quarter)	2-1
CS 2501	Introduction to Computer Systems (Second half of quarter)	2-0

Science and Engineering

EE 2721	Introduction to Electronic Systems	4-1
OC 2120	Survey of Oceanography	4-0
PH 2252	Introduction to the Thermal and Dynamic Properties of Gases and Liquids	3-0

Graduate Study

The graduate program consists of integrated course offerings in several disciplines related to ASW; a sequence of 3 elective courses selected from a particular discipline; and a group project or thesis occupying the equivalent of four course slots. The required graduate courses are listed below.

ST 3000	Study Project on ASW Systems Performance	0-2
ST 3180	Electromagnetic Wave Propagation	4-2
ST 3181	Non-Acoustic Sensor Systems	4-0
ST 3340	The Defense Decision Process and ASW Warfare	4-0
ST 3390	Computation and Computer Simulation	4-2
PH 3471	Fundamentals of Acoustics	4-2
PH 3472	Underwater Acoustics	4-2
OC 3265	Environmental Factors in Underwater Acoustics	4-0
OC 3625	Environmental Prediction for Underwater Sound Propagation	3-2
MR 3413	Meteorology for Operational Systems Technology (ASW)	4-0
EE 3714	Introduction to Signals and Noise	4-1
EE 4716	Signal Processing Systems	4-1
OS 3651	Search, Detection and Localization Models	4-0

OS 3652	Introduction to Combat Models and Weapons Effectiveness	4-1
OS 3661	Decision Analysis and Data Analysis	4-0
OS 3665	Human Vigilance Performance	3-1
OS 4643	ASW War Gaming	3-0
OS 4665	Systems Psychology	4-0

The three electives can be chosen from a wide variety of courses related to ASW; the thesis or group project will be arranged in consultation with the Naval Postgraduate School staff and faculty.

Thesis/Group Project

In this program the officer student may elect to do an individual thesis under the direction of a faculty member or to participate in a group project with two or three other students and several faculty members. In either case, the effort will be directed toward some problem related to ASW.

Seminar

During each quarter of the curriculum every student will be enrolled in a seminar course, ST 0001, which provides time for guest speakers, discussions of ASW matters, and other special activities related to the program.

ENGINEERING ACOUSTICS CURRICULUM
CURRICULUM NUMBER 535
(GROUP UX)

OBJECTIVE (SPECIFIC)—To provide the student with a firm comprehension of the principles of underwater acoustic systems. The curriculum convenes annually in September.

DESCRIPTION (SPECIFIC)—This curriculum is interdisciplinary in nature with primary emphasis on acoustics and electrical engineering. Specific coverage is provided in such areas as propagation of sound in the sea, transducer theory, signal processing, electronics, oceanography, and noise and vibration control. Successful completion of the curriculum permits the graduate to address current and future military problems associated with underwater acoustic systems and to expand his base of professional knowledge and technical competence. The graduates will be qualified to participate professionally in the development, design, operation, integration and management of the Navy's complex acoustical systems, will be awarded an appropriate subspecialty billet code and the degree Master of Science in Engineering Acoustics.

Introductory Study

This portion of the program provides the necessary mathematics, electrical engineering, and physics required for successful pursuit of the graduate curriculum. Each student's transcript will be evaluated for validation of as many of these courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

Mathematics

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
MA 2121	Differential Equations	4-0
MA 2161	Introduction to Mathematical Physics	5-0
MA 2232	Numerical Methods	3-1
MA 3132	Partial Differential Equations and Integral Transforms	4-0

Physics and Electrical Engineering

PH 1051	Review of Vector Mechanics and Introduction to Fluids	4-2
PH 2552	Introduction to the Thermal and Dynamic Properties of Gases and Liquids	3-0
PH 2260	Optical Physics	4-2
PH 2351	Electromagnetism I	4-0
PH 2352	Electromagnetism II	4-0
EE 2101	Basic Circuit Theory	3-2
EE 2102	Circuit Analysis	4-2
EE 2103	Linear Systems Analysis	4-2
EE 2114	Communication Theory I	4-0
EE 2211	Electronic Engineering Fundamentals I	4-2
EE 2212	Electronic Engineering Fundamentals II	4-3

Oceanography

OC 2120	Survey of Oceanography	4-0

Graduate Study

The graduate portion of the program includes most of the following courses and a thesis.

Physics

PH 3161	Physics of Underwater Vehicles	4-1
PH 3451	Fundamental Acoustics	4-1
PH 3452	Underwater Acoustics	4-2
PH 4453	Propagation of Waves in Fluids	4-0
PH 4454	Transducer Theory and Design	3-2
PH 4455	Advanced Acoustics Laboratory	0-3
PH 4456	Seminar in Applications of Underwater Sound	3-0

Electrical Engineering

EE 3116	Communication Theory II	3-2
EE 4451	Sonar Systems Engineering	3-2
EE 4541	Discrete Signal Processing	3-1

Other

OC 3261	Oceanographic Factors in Underwater Sound	4-0
ME 3500	Mechanical Vibrations and Noise Control	4-0

NUCLEAR SCIENCE CURRICULUM
CURRICULUM NUMBER 521
(GROUP FA)

OBJECTIVE (SPECIFIC)—to provide the officer with a well-founded comprehension of scientific and technical principles underlying the blast, thermal, and radiation effects associated with nuclear weapons and materials. The curriculum convenes in September.

DESCRIPTION (SPECIFIC)—Principal studies are undertaken in classical and modern physics as the foundation sciences to understand these effects. Concurrent studies of electrical and electronic devices and circuits, as well as studies in other fields such as operations analysis, complete this comprehensive program. Specialized areas of study include nuclear processes, plasmas, radiation and thermal effects in matter (including electronic devices and living organisms), generation and propagation of shock waves, and properties of the upper atmosphere. Thesis research is normally conducted in one of these areas of specialized study. Comple-

tion of the curriculum permits the officer to more knowledgeably address current and future military problems associated with weapons effects and nuclear material utilization, and expands his base of professional knowledge and technical competence.

Naval officers graduating from this program are awarded the appropriate subspecialty billet code and the degree Master of Science in Physics.

Introductory Study

This portion of the program is identical to that listed for the Electro-optics/Laser Technology option of Curriculum 530.

Graduate Study

The graduate program consists of required courses and a thesis. The typical graduate program is 4 or 5 quarters in length, depending on previous academic background.

Typical Graduate Courses

PH 3280	Electro-optics	4-2
PH 3461	Explosive Shock Waves	4-0
PH 3561	Introductory Statistical Physics	4-0
PH 3651	Atomic Physics	4-2
PH 3652	Elements of Molecular, Solid State, and Nuclear Physics	4-2
PH 3951	Introduction to Quantum Mechanics	4-0
PH 4353	Electromagnetism III	3-0
PH 4661	Plasma Physics I	4-0
PH 4750	Radiation Effects in Solids	5-0
PH 4851	Nuclear Physics I	4-2
PH 4885	Reactor Theory	3-0
BI 3850	Biological Effects of Radiation	5-0

ADVANCED SCIENCE CURRICULUM CURRICULUM NUMBER 380

OBJECTIVE (SPECIFIC)—To prepare selected officers to deal with the problems of fundamental and applied research in the fields of physics or applied mathematics.

QUALIFICATIONS FOR ADMISSION—Officers nominated for the Advanced Science Curriculum are normally selected from those first-year students enrolled at the Naval Postgraduate School who apply for the Advanced Science Program. Applicants are screened, and those having a very good academic background and appearing to have an excellent chance of succeeding in their chosen field, may be selected.

DESCRIPTION (SPECIFIC)—Officers selected for Advanced Science Curricula complete their first year at the Naval Postgraduate School, and may spend a second and third year of study either at the Naval Postgraduate School or a civilian university. The curriculum for each officer is arranged from courses selected to suit the needs of the parent service, to develop the potential of the individual student, and to meet mutually beneficial career objectives.

The Advanced Science Curriculum normally leads to the Master of Science degree.

Major Robert M. Berg, U.S. Air Force, receiving congratulations from Rear Admiral Freeman for his contribution to the Navy Sailing Association at the Postgraduate School.

CURRICULA CONDUCTED AT CIVILIAN UNIVERSITIES

Curriculum	*Number*	*Length*	*Institution*	*Curricular-Supervisory Control Authority*
Business Administration	810	2 yrs.	Cornell U	NAVSUPSYSCOM
			Duke U	NAVSUPSYSCOM
			U. of Mich	NAVSUPSYSCOM
			U. of N. C.	NAVSUPSYSCOM
			U. of Pa.	NAVSUPSYSCOM
			U. of Va.	NAVSUPSYSCOM
Civil Engineering (Advanced)	470	1-2 yrs.	U. of Fla.*	NAVFACENGCOM
Typical Options:			Georgia Tech	NAVFACENGCOM
Structures			U. of Hawaii*	NAVFACENGCOM
Soil Mechanics			M. I. T.	NAVFACENGCOM
Sanitary Engineering			Purdue	NAVFACENGCOM
Waterfront Facilities			R. P. I.	NAVFACENGCOM
Facilities Planning			Texas A&M	NAVFACENGCOM
Construction Engineering			Tulane	NAVFACENGCOM
Civil Engineering Administration			U. of Cal. (Berkeley)	NAVFACENGCOM
Deep Ocean Construction Engineering			U. of Colo	NAVFACENGCOM
			U. of Ill.	NAVFACENGCOM
			U. of Mich	NAVFACENGCOM
			U. of Minn	NAVFACENGCOM
			U. of Wash	NAVFACENGCOM
Criminal Law	884	12 mos.	Geo. Wash. U*	JAG
Electrical/Electronics Engineering (CEC)	471	12-18 mos.	Ga. I. T.	NAVFACENGCOM
			M. I. T.	NAVFACENGCOM
			Purdue	NAVFACENGCOM
			R. P. I.	NAVFACENGCOM
			U. of Cal. (Berkeley)	NAVFACENGCOM
			U. of Colo.	NAVFACENGCOM
			U. of Ill.	NAVFACENGCOM
			U. of Mich.	NAVFACENGCOM
Financial Management	812	1 yr.	Geo. Wash. U.*	NAVCOMP
Forensic Science	885	1 yr.	Armed Forces Institute of Pathology*	JAG
Hydrographic Engineering (Geodesy)	475	2 yrs.	Ohio St. U.	OCEANAV
International Law	672	1 yr.	Geo. Wash. U.*	JAG
International Relations	671	1 yr.	Various	BUPERS
Law (Army Judge Advocate Officers Advanced Course)	881	9 mos.	U. of Virginia	JAG
Management and Industrial Engineering	540	1 yr.	R. P. I.	NAVORD/AIRSYSCOM
Mechanical Engineering (CEC)	473	1 yr.	Various	NAVFACENGCOM
Naval Construction and Engineering	510	2/3 yrs.	M. I. T.	NAVSHIPSYSCOM
Nuclear Power Engineering (CEC)	572	18 mos.	Penn. State U.	NAVFACENGCOM
Nuclear Power Engineering (ED)	520	18 mos.	Penn. State U.	NAVFACENGCOM/NAVSHIPS
			U. of Mich.	NAVSHIPSYSCOM
Ocean Law	883	12 mos.	Various	JAG

**No NROTC unit at Institution.*

Curriculum	*Number*	*Length*	*Institution*	*Control Authority Curricular-Supervisory*
Petroleum Administration and Management	880	1 yr.	Various	JAG
Petroleum Engineering (CEC)	630	1 yr. 6-12 mos.	U. of Texas Industry	NAVFACENGCOM
Petroleum Management	811	17 mos.	U. of Kansas	NAVSUPSYSCOM
Political Science	680	2 yrs.	U. of Wash. Various	OPNAV (OP-61) OPNAV (OP-61)
Procurement Management	815	12 mos.	Geo. Wash. U.	NAVSUPSYSCOM
Public Relations	920	18 mos.	Various	CHINFO
Religion	970	9 mos.	Various	Chief of Chaplains
Retailing	830	1 yr.	Mich. State*	NAVSUPSYSCOM
Subsistence Technology	860	1 yr.	Mich. State*	NAVSUPSYSCOM
Systems Inventory Management	819	2 yrs.	Duke U. U. of Mich M. I. T.	NAVSUPSYSCOM NAVSUPSYSCOM NAVSUPSYSCOM
Taxation	882	1 yr.	Various	JAG
Transportation Management	813	1 yr.	Mich. State*	NAVSUPSYSCOM

**No NROTC unit at Institution.*

CURRICULA AT OTHER UNIVERSITIES

The curricula listed in this section are conducted entirely at civilian educational institutions. Quotas for enrollment must be approved by the Chief of Naval Personnel and the Chief of Naval Education and Training. The table indicates the duration of each curriculum, the location, and the curricular supervisory control authority. Administration of officer students in connection with educational matters is exercised by the Superintendent, Naval Postgraduate School, through the Commanding Officer, NROTC Unit, or through the Senior Officer Student at those institutions where no NROTC Unit is established.

The information on courses is taken from college catalogues, but is subject to change from year to year. Changes depend on scheduling problems at the educational institutions and on the academic backgrounds of students. Further detailed information can be obtained from the catalogue of the institution concerned or by writing to the institution.

BUSINESS ADMINISTRATION CURRICULUM NUMBER 810

At: Cornell University
Duke University
University of Michigan
University of North Carolina
University of Pennsylvania
University of Virginia

OBJECTIVE—To provide officers graduate-level education in the fields of business administration.

CIVIL ENGINEERING (ADVANCED) CURRICULUM NUMBER 470

At: Georgia Institute of Technology
Massachusetts Institute of Technology
Purdue University
Rensselaer Polytechnic Institute
Texas A&M
Tulane University
University of California (Berkeley)
University of Colorado
University of Florida
University of Hawaii
University of Illinois
University of Michigan
University of Minnesota
University of Washington

OBJECTIVE—To educate officers for civil engineering duties. Options are available in all major fields of civil engineering. Typical options are: construction engineering, structures, soil mechanics, sanitary environmental engineering. Officers without previous civil engineering education would undertake a two-year curriculum; officers holding a Bachelor of Civil Engineering degree would undertake a one-year to 18 month curriculum. This program is to qualify line officers (1100) for civil engineering duties and to provide advanced education for Civil Engineering Corps officers (5100).

Course length: One to two years

Degree attainable: Master of Science in Civil Engineering

CRIMINAL LAW CURRICULUM NUMBER 884

At: George Washington University

OBJECTIVE—To provide officers of the JAG Corps graduate level education in the field of criminal law.

Course length: Twelve months

Degree attainable: Master of Laws

ELECTRICAL/ELECTRONICS ENGINEERING (CEC) CURRICULUM NUMBER 471

At: Georgia Institute of Technology
Massachusetts Institute of Technology
Purdue University
Rensselaer Polytechnic Institute
University of California (Berkeley)
University of Colorado
University of Illinois
University of Michigan

OBJECTIVE—To provide advanced education for selected CEC officers in electrical engineering with emphasis on power plants and electrical power distribution. Other available options include: engineering systems and design, electromagnetic field theory, and electric utilities management.

Course length: 12 to 18 months

Degree attainable: Master of Science in Electrical Engineering

FINANCIAL MANAGEMENT CURRICULUM NUMBER 812

At: George Washington University

OBJECTIVE—To develop in officers of mature judgment and a broad background of professional experience the ability to interpret and analyze operational statistics for the purpose of developing standards of performance to provide a periodic review of operations in order to denote areas of management which are not meeting standards; to review budget estimates; and to plan programs for the improvement of management economy and efficiency through better organization, administration and procedures and better utilization of manpower, materials, facilities, funds, and time. The course is designed to give graduates a working knowledge of managerial controls adequate for assignment to financial management duties as a normal preparation for command and executive billets in the shore establishment.

Course length: One year

Degree attainable: Master of Science in Business Administration.

Typical Curriculum:

Undergraduate:

Survey of Accounting
Industrial and Governmental Economics
Statistical Decision Making
Management Communication

Graduate:

Cost Accounting
Managerial Accounting
Internal Control and Auditing
Survey of Data Processing
Financial Management
Seminar in Marketing
Business Organization and Management
Management Engineering
Readings and Conferences in Financial Management
Research Seminar
Research Seminar in Comptrollership
Human Relations in Administration
Governmental Budgeting

FORENSIC SCIENCE CURRICULUM NUMBER 885

At: Armed Forces Institute of Pathology

OBJECTIVE—To provide officers of JAG Corps with graduate level education in the field of forensic science.

Course length: Twelve months

Degree attainable: Master of Laws

HYDROGRAPHIC ENGINEERING (GEODESY) CURRICULUM NUMBER 475

At: Ohio State University

OBJECTIVE—To prepare officers for assignment to duties at the Oceanographic Office, on geodetic survey expeditions, and fleet staffs. The curriculum presents a fundamental theoretical knowledge of geodesy, cartography, and photogrammetry, particularly as applied to hydrographic surveying and the compilation and production of charts and maps.

Course length: Two years

Degree attainable: Master of Science in Geology

INTERNATIONAL LAW CURRICULUM NUMBER 672

At: George Washington University

OBJECTIVE—To prepare Judge Advocate General Corps Officers (2500) for duties involving problems of international law. The course encompasses international law and agreements including the law of air, sea, and space legal aspects of U. S. foreign relations, negotiations, and legal regulation of international coercion. A thesis on a topic of significant international law interest is required. In addition, certain studies of a geographic area selected by the student will be conducted.

Course length: One year

Degree attainable: Master of Laws

INTERNATIONAL RELATIONS CURRICULUM NUMBER 671

At: Various universities

OBJECTIVE—To provide a broad understanding of the forces and factors in international relations to equip officers to meet responsibilities involving knowledge of the international situation, including awareness of the role of sea power in world affairs.

Course length: One year

Degree Attainable: Master of Arts

LAW CURRICULUM NUMBER 881

(Army Judge Advocate Officers Advanced Course)

At: University of Virigina

OBJECTIVE—To prepare more experienced Judge Advocate General Corps Officers (2500) for advanced staff responsibilities in the various legal fields. The course encompasses all branches of military law with emphasis on the administration of the Uniform Code of Military Justice, military affairs, civil affairs arising out of the operation of or litigation of military law including the laws of war, procurement and contract law, and legal assistance to military personnel.

Course length: Nine months

MANAGEMENT AND INDUSTRIAL ENGINEERING CURRICULUM NUMBER 540

At: Rensselaer Polytechnic Institute

OBJECTIVE—To prepare selected officers for managerial and industrial engineering billets in the Navy's industrial organization. The curriculum majors in industrial engineering and its application to managerial problems.

Course length: One year

Degree attainable: Master of Science in Management Engineering

Typical Curriculum:

Summer:
Review of Quantitative Methods
Statistical Methods
Law in Management and Engineering
Data Processing

Fall:
Cost Finding and Control
New Product Problems or
Organization and Management of Marketing
Organization Planning and Development
Industrial Relations
Production Management I

Spring:
Administrative Practice and Behavior
Financial Planning and Control
Seminar in Management
Production Management II
Analytical Methods in Management

MECHANICAL ENGINEERING (CEC) CURRICULUM NUMBER 473

At: Various universities

OBJECTIVE—To provide advanced education for selected CEC officers in mechanical engineering with emphasis on power plants, heating and ventilation, and utilities management.

Course length: One year

Degree attainable: Master of Science in Mechanical Engineering

NAVAL CONSTRUCTION AND ENGINEERING CURRICULUM NUMBER 510

At: Massachusetts Institute of Technology

OBJECTIVE—To prepare officers to engage in Ship Systems Engineering from the concept of the "whole ship." The curricula centers around the broad field of Naval Architecture supplemented with options in the following areas:

Structures
Hydrodynamics and Ship Control
Ocean Engineering (General)
Ocean Engineering (Underwater Sensing and Communications)
Mechanical Engineering (Control Systems or Propulsion)
Nuclear Engineering
Electrical Engineering (Above Water Sensing and Communications or Underwater Sensing and Communications or Power Generation and Transmission)

An additional option available for qualified students involves studies in the Sloan School of Management in a "Dual Masters Program."

Selection of options is made after completion of the initial summer term (students report in June for this program). Exceptional students are encouraged to pursue advanced work to the doctoral level if career consideration permits.

For the third summer a "Professional Summer" is planned where rigorous advanced technology material will be offered to students attending this program. This material (which will be classified if necessary) will insure the relevancy of the program to the Naval Officer's professional involvement in highly sophisticated total ship systems.

Course length: Two or Three years

Degree attainable: Naval Engineer with a lesser included degree of Master of Science in that option selected by the student. Those students who choose the Dual Engineering/Management program receive two M. S. degrees, one in Naval Architecture and one in Management. Some students, electing only a two year program, can earn two technical M.S. degrees, one in Naval Architecture and one in the option selected by the student.

NUCLEAR POWER ENGINEERING (CEC) CURRICULUM NUMBER 572

At: The Pennsylvania State University

OBJECTIVE—To provide education for selected CEC officers in nuclear power engineering. Graduates of this curriculum will normally be assigned duties in the shore nuclear power program under the technical direction of the NAVFACENGCOM.

Course length: 18 months

Degree attainable: Master of Science

NUCLEAR POWER ENGINEERING (ED) CURRICULUM NUMBER 520

At: Penn State University
University of Michigan

OBJECTIVE—To provide education for selected officers in nuclear power engineering. Graduates of this curriculum will normally be assigned duties in the shore nuclear power program under the technical direction of the NAVFACENGCOM or NAVSHIPSYSCOM.

Course length: 18 months

Degree attainable: Master of Science

OCEAN LAW CURRICULUM NUMBER 883

At: Various universities

OBJECTIVE—To provide officers of JAG Corps with graduate level education in the field of maritime law.

Course length: Twelve months

Degree attainable: Master of Laws

PETROLEUM ADMINISTRATION AND MANAGEMENT (Gas, Oil and Water Rights) CURRICULUM NUMBER 880

At: Southern Methodist University

OBJECTIVE—To provide Judge Advocate General Corps Officers (2500) with a study of government regulations in oil and gas law taxation problems, and special research and study of the evolution of law concerning water rights, current law affecting these rights, and technical problems attendant thereto so as to prepare them for assignment to billets concerned with the administration and management of the Naval Petroleum and Oil Shale Reserves and with the special problems in the field of water rights.

Course length: One year

Degree attainable: Master of Laws in Oil and Gas

PETROLEUM ENGINEERING (CEC) CURRICULUM NUMBER 630

At: University of Texas and in the petroleum industry

OBJECTIVE—To prepare selected CEC officers for assignments to duty involving the administration and operations of Naval Petroleum and Oil Shale Reserves. The curriculum provides the student with a knowledge of petroleum development and production procedures, geology, petroleum economics and reservoir engineering.

Course length: One year of academic work followed by 6 months in the field with a major oil company

Degree attainable: Master of Science in Petroleum Engineering

PETROLEUM MANAGEMENT CURRICULUM NUMBER 811

At: University of Kansas

OBJECTIVE—To provide officers of the Supply Corps graduate level education in the functional proficiency field of petroleum management and administration.

Course length: Seventeen months

Degree attainable: Master of Science

Typical Curriculum:

Fall:
Quantitative Analysis I
Material and Energy
Development of Oil and Gas Lands
Theoretical Principles of Petroleum Production

Spring:
Quantitative Analysis II
Field Practice in Natural Gas
Appraisal of Oil and Gas Properties
Research

Summer:
Personnel Management
Legal Aspects of Business Research

Fall:
Petroleum Management Research

POLITICAL SCIENCE CURRICULUM NUMBER 680

At: University of Washington
Various other universities

OBJECTIVE—To equip a limited number of intellectually mature officers with a broad professional background in international relations in order that they may provide professional advice and assistance in the formulation and execution of national policy. Studies should be specifically directed toward obtaining sound knowledge and understanding in:

(1) The theory of international politics, economics, law, and U. S. diplomatic history.

(2) The politics, geography, and history of one of the following regions of the world: Europe, Asia, Africa, Western Hemisphere.

(3) The history, role and importance of worldwide and regional international organizations.

(4) Development and execution of U. S. political, military and economics policy as it pertains to U. S. foreign relations.

Course length: Two years

Degree attainable: Master of Arts

PROCUREMENT MANAGEMENT CURRICULUM NUMBER 815

At: George Washington University

OBJECTIVE—To provide officers of the Supply Corps graduate level education in the field of military and commercial procurement:

Course length: One year

Degree attainable: Master of Business Administration

PUBLIC RELATIONS CURRICULUM NUMBER 920

At: Various universities

OBJECTIVE—To provide advanced qualifications of officers in the field of public relations. Officers selected for program must have previous education or experience in public information and public relations. This curriculum will be made up from regular course offerings of the university and will be based on an officer student's background and particular interest within the curricular area.

Course length: One year to 18 months

Degree attainable: Master of Arts in Public Relations

RELIGION CURRICULUM NUMBER 970

At: Various universities

OBJECTIVE—To broaden the education of officer students in such fields as psychology, theology, homiletics, and counseling, hospital ministry and education.

Course length: 9 months

RETAILING CURRICULUM NUMBER 830

At: Michigan State University

OBJECTIVE—To provide officers of the Supply Corps with graduate level education in the functional proficiency field of retailing. Emphasis is placed on consumer markets, sales promotion, merchandise and merchandising, and the management functions associated therewith.

Course length: One year

Degree attainable: Master of Business Administration

SUBSISTENCE TECHNOLOGY CURRICULUM NUMBER 860

At: Michigan State University

OBJECTIVE—To provide officers of the Supply Corps with graduate level education in the field of food management.

Course length: One year

Degree attainable: Master of Business Administration

SYSTEMS INVENTORY MANAGEMENT CURRICULUM NUMBER 819

At: Duke University, University of Michigan

OBJECTIVE—To provide officers of the Supply Corps with a well-grounded education at the graduate level in the scientific methods of inventory management.

Course length: Two years

Degree attainable: Master of Business Administration

TAXATION CURRICULUM NUMBER 882

At: Various universities

OBJECTIVE—To provide officers of the JAG Corps graduate level education in the field of taxation.

Course length: Twelve months

Degree attainable: Master of Laws

TRANSPORTATION MANAGEMENT CURRICULUM NUMBER 813

At: Michigan State University

OBJECTIVE—To provide officers of the Supply Corps with graduate level education in the functional proficiency field of transportation management.

Course length: One year

Degree attainable: Master of Business Administration

Typical Curriculum:
- Basic Accounting II
- Financial Management
- Basic Marketing
- Basic Statistics I
- Accounting for Financial and Profit Management II
- Problems in Business Economics
- Basic Statistics II
- Transportation Policy
- Accounting for Financial and Profit Management III
- Human Problems in Administration
- Social Problems in Administration
- Marketing Management
- Transportation Seminar

ACADEMIC DEPARTMENTS and COURSE DESCRIPTIONS

DEPARTMENT OF AERONAUTICS

RICHARD WILLIAM BELL, Professor of Aeronautics; Chairman (1951)*; A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

ROBERT EDWIN BALL, Associate Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

MILTON HAROLD BANK, II, Assistant Professor of Aeronautics (1971); B.S., Naval Academy, 1957; B.S.A.E., Naval Postgraduate School, 1964; Engr., Stanford, 1967; M.S., Georgia Institute of Technology, 1970; Ph.D., 1971.

OSCAR BIBLARZ, Associate Professor of Aeronautics (1968), B.S., Univ. of California at Los Angeles, 1959; M.S., 1963; Ph.D., Stanford Univ., 1968.

HARVEY WORTH BURDEN, Lieutenant Commander, U.S. Navy; Assistant Professor of Aeronautics (1973); B.S., Naval Academy, 1955; B.S.A.E., Naval Postgraduate School, 1963; AeE, California Institute of Technology, 1964; Ph.D., Univ. of Pennsylvania, 1969.

DANIEL JOSEPH COLLINS, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

ALLEN EUGENE FUHS, Professor of Aeronautics (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

THEODORE HENRY GAWAIN, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

RONALD ANDREW HESS, Assistant Professor of Aeronautics (1970); B.S.A.E., Univ. of Cincinnati, 1965; M.S.A.E., 1967; Ph.D., 1970.

CHARLES HORACE KAHR, JR., Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

DONALD MERRILL LAYTON, Associate Professor of Aeronautics (1965); B.S., Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954; M.S., Naval Postgraduate School, 1968.

GERALD HERBERT LINDSEY, Associate Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ. 1960; M.S., 1962; Ph.D., California Institute of Technology, 1966.

JAMES AVERY MILLER, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

DAVID WILLIS NETZER, Associate Professor of Aeronautics, (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ. 1962; Ph.D., 1968.

MAX FRANZ PLATZER, Associate Professor of Aeronautics (1970); Dipl Ing., Tech. Univ. of Vienna, Austria, 1957; Dr. Techn. Sci., 1964.

HOWARD LEON POWER, Assistant Professor of Aeronautics (1971); B.S.A.E., Iowa State Univ., 1963; M.S.A.E., Stanford Univ. 1967; Ph.D., Iowa State Univ. 1971.

LOUIS VINCENT SCHMIDT, Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

RAYMOND PARMOUS SHREEVE, Visiting Professor of Aeronautics (1971); B.Sc., Imperial College, London 1958; M.S.E., Princeton Univ. 1961; Ph.D., Univ. of Washington, 1970.

MICHAEL HANS VAVRA, Distinguished Professor of Aeronautics, (1947); Dipl. Ing., Swiss Federal Institute of Technology, 1934; Ph.D., Univ. of Vienna, 1958.

ROBERT DIEFENDORF ZUCKER, Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

EMERITUS FACULTY

WENDELL MAROIS COATES, Distinguished Professor Emeritus (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

ULRICH HAUPT, Associate Professor Emeritus (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

GEORGE JUDSON HIGGINS, Professor Emeritus (1942); B.S., in Eng. (Ae.E.), Univ. of Michigan, 1923; Ae.E., 1934.

HENRY LEBRECHT KOHLER, Professor Emeritus (1943); B.S., in M.E., Univ. of Illinois, 1929; M.S. in M.E., Yale Univ., 1930; M.E., 1931.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of degrees as determined by the Aeronautics Department. In addition the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement for study in the Aeronautics Department generally is a baccalaureate in engineering earned with above average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering but who have had adequate coverage in the basic physical and mathematical sciences. All entrants must obtain the approval of the Chairman, Department of Aeronautics.

Students who have not majored in Aeronautics, or who have experienced a significant lapse in continuity with previous academic work, initially will take a Core of courses in aeronautical engineering and mathematics at the upper division level. The Core, consisting of 2000 and 3000 level courses, extends through the first three academic quarters and constitutes a portion of the coursework for degrees in Aeronautics. Final approval of programs leading

to degrees in Aeronautical Engineering must be obtained from the Chairman, Department of Aeronautics.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

Upon completing the Core, students may be selected on the basis of academic performance for the degree program leading to the Master of Science in Aeronautical Engineering. However, students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program.

The Master of Science degree requires a minimum of 36 credit hours of graduate courses beyond the Core, of which at least 20 credit hours shall be at the 4000 level. It also requires that not less than 32 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 20 hours of courses in the Department of Aeronautics and a minimum of 8 hours in other departments.

An acceptable thesis is required for the degree unless waived by the Chairman, Department of Aeronautics, in which case 10 quarter hours of 4000 level courses in the disciplines of engineering, physical science, or mathematics will be required in addition to those specified above, increasing the total requirement to 46 quarter hours of graduate level credits.

AERONAUTICAL ENGINEER

Upon completing the Core, students may be selected on the basis of academic performance for the program leading to the degree Aeronautical Engineer. Selection to this degree program shall be limited to those students who, in the opinion of the faculty, have the potential to conduct the required research.

The degree Aeronautical Engineer requires a minimum of 72 credit hours of graduate courses beyond the Core, of which at least 48 credit hours shall be at the 4000 level. It also requires that not less than 64 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 36 hours of courses in the Department of Aeronautics and a minimum of 12 hours in other departments. An acceptable thesis is required for the degree.

Students admitted to work for the degree Aeronautical Engineer may be satisfying requirements for the Master of Science degree concurrently. The Master of Science in Aeronautical Engineering may be conferred at the time of completion of the requirements for that degree.

DOCTOR OF PHILOSOPHY

The Department of Aeronautics offers programs leading to the Ph.D. degree in the fields of gas dynamics, flight structures, flight dynamics, propulsion and aerospace physics.

Entrance into the doctorate program may be requested by officers currently enrolled who have completed the Aero Common Core with a sufficiently high standing. The Department of Aeronautics also accepts officer students selected in the Navy-wide Doctoral Study Program, and civilian students selected in the School's Co-operative Doctoral Program with the Navy and other Defense Laboratories. The Co-operative Doctoral Program is described further in another section of this catalogue.

All applicants for the Ph.D. Program who are not already enrolled as students in the Department of Aeronautics shall submit transcripts of their previous academic and professional records and letters of recommendation to the Department Chairman. The Chairman, with the advice of other department members, shall decide whether to admit the applicant to the Doctoral Program.

Every applicant who is accepted for the Doctoral Program will initially be enrolled in the AeE Program under a special option which satisfies the broad departmental requirements for the Engineer's degree and which includes research work. As soon as feasible, the student must find a faculty adviser to supervise his research and help him initially in the formulation of his plans for advanced study. As early as practicable thereafter, a Doctoral Committee shall be appointed to oversee that student's individual Doctoral Program as provided in the school-wide requirements for the Doctor's degree.

The degree requirements are as outlined under the general school requirements for the Doctor's degree.

In the event that a student is unable finally to satisfy the above requirements for the doctorate for any reason but has in the course of his doctoral studies actually completed all of the requirements for the degree of Aeronautical Engineer, he shall be awarded the latter degree.

AERONAUTICAL LABORATORIES

Six major laboratory divisions facilitate instructional and research programs in subsonic aerodynamics, structural test, rocket propulsion, cascades and turbomachinery, flight dynamics and gas dynamics.

The subsonic aerodynamics laboratory consists of two low-speed, continuous flow wind tunnels and a large, continuous flow visualization tunnel. Standard techniques are used in the 32×45 inch and 42×60 inch wind tunnels to measure quantities such as steady and unsteady velocities, pressures, loads and hinge moments for the studying of basic fluid flows about bodies, stability and control of aerodynamic vehicles, and unsteady flows about bluff bodies and lifting surfaces. The three-dimensional flow visualization tunnel has a basic test section of $5 \times 5 \times 12$ feet expandable to $15 \times 15 \times 12$ feet. Helium bubble filaments are pulsed and may be studied stroboscopically and photographed to define the flow field in many applications, e.g., helicopter blade and jet flap flow visualization.

The structural test laboratory contains testing machines with varying capacities up to 300,000 pounds for demonstration and analysis of relatively small structures. Large aircraft components, such as a P2C-2 wing and a F8U-3 wing are accommodated on a special loading floor of the laboratory where static and vibration tests are conducted. An adjacent strain-gage and instrumentation laboratory is employed for instruction in structural testing techniques. A well equipped dynamics laboratory contains shaker tables, analog computers, and as-

sociated electronic instrumentation. Class work and research are conducted in various areas of applied mechanics such as non-linear structural dynamics, elastic wave propagation, and dynamic transfer function evaluation.

The rocket laboratory consists of an instrumented control room, a propellant chemistry laboratory, a high pressure air facility and three test cells. The test cells are equipped for investigating solid, liquid, gaseous and hybrid rocket combustion. In addition, one test cell is equipped for internal ballistics studies of small caliber cannon. Major equipment includes a high acceleration centrifuge, a photographically equipped centrifuge, a bi-phase rocket motor, a gas chromatograph, and combustion bombs for optical studies of solid propellant combustion. A solid fuel ramjet test facility is also in operation. The ramjet utilizes the hot-air start system in the jet engine test cells.

The advanced facilities of the cascade and turbomachinery laboratories are distributed in three buildings, one of which provides low speed tests with rectilinear cascades of large dimensions. The source of air is a 700 HP fan, either to draw or to blow air through the test items, which delivers about 100,000 cfm of air at a pressure difference of about 40 inches of water. This source can be used also to perform model tests with flow channels, inlet and discharge casings, scrolls and diffusors. The special rectilinear cascade test rig is equipped with semi-automatic instrumentation; data are obtained with an electronic logging system for data reduction on digital computers. A second building houses a centrifugal compressor test rig, instrumented for conventional performance measurements and for special investigations of three-dimensional flows about both the stationary and the rotating vanes. The third building is used for high speed tests, in three test cells, monitored from a central control room. A 1250 HP variable-speed axial-flow compressor, which is instrumented also for interstage measurements, produces high pressure air either for turbine testing, or to drive test compressors, pumps, and other test items. This building contains many different types of turbomachinery including a 3-stage axial flow compressor, a transonic axial test rig with vacuum exhauster system, a radial turbine test rig, a transonic compressor test rig, a critical shaft speed test bench, a 3-stage centrifugal compressor and a radial compressor test rig. An adjacent control room contains a complete data acquisition system. Adjacent to the third building is a hotspin test unit, where disks and propellers can be rotated at speeds up to 50,000 rpm. Heating and cooling elements make it possible to impose radial temperature gradients. Instrumentation is provided to conduct stress work, with strain gauges, up to 27,000 rpm and a maximum temperature of 1800°F. Also available are a probe calibration tunnel with annular cross section for the calibration of pressure and hotwire probes.

The flight mechanics laboratory utilizes a light, twin-engine general aviation aircraft which has three test stations, each instrumented to display airspeed, pressure altitude, normal acceleration, angle of attack, angle of sideslip and control force and position. In addition, a variable stability cockpit simulator is used in conjunction with the Computer Science hybrid computer and graphic displays for both fixed wing and rotary wing problems. Other simulators include a two degree of freedom, fixed base facility used to study aircraft control problems and a fixed base, six degree of freedom visual simulator with a video display.

The gas dynamics laboratory includes a blow-down supersonic wind tunnel having a 4×4 inch test section and an operating Mach number range from 1.4 to 4. Instruments associated with this facility include 6" and 9" Mach Zehnder interferometers and 5" and 9" Schlieren systems for flow observations. A ruby Q-switched holographic laser is also available for flow field visualization. A cold-driven, three inch, double-diaphragm shock tube has been constructed for measurement of the thermal conductivity of noble gases and for the study of vibration relaxation, gas dissociation, and ionization. He-Ne, Argon, and CO_2 lasers are utilized in various experiments including a Gaertner-Jeong holography system. An electrohydrodynamic research facility in which electric power generation and turbulence are being studied, and a coaxial plasma accelerator, have recently been completed. Another facility is an open circuit oscillating flow wind tunnel, two feet square and 18 feet long, in which nearly sinusoidal perturbations may be superimposed on the free stream flow by means of a series of four synchronously driven rotating shutters; frequencies of 0.1 to 250 cps may be obtained. Principal instrumentation available for this tunnel is a ten channel constant-temperature linearized hotwire anemometer.

In addition to the major laboratory facilities, a ballistic range is available for basic research in such topics as aircraft vulnerbility and exterior ballistics. This range is instrumented to measure fluid and structural response events which occur in microsecond time scales. The Department also operates a three ton Surface Effect Ship testcraft of the Captured Air Bubble type.

A computation laboratory has been established to facilitate analytical solutions of classroom and research problems. A remote console for the Naval Postgraduate School IBM 360-67 computer is available, together with a mini-computer complex and numerous electronic desk calculators.

GENERAL PREREQUISITE REQUIREMENTS

Unless otherwise stated the common core of courses for the first three quarters, or equivalent preparation to be approved by the Chairman, Department of Aeronautics, is prerequisite to all other aeronautics courses.

AERONAUTICS

AE 0010 AERONAUTICAL ENGINEERING SEMINAR (0-I). Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

AE 0020 AERONAUTICAL ENGINEERING PROGRAM PLANNING (0-I). Oral presentations by the Aero Academic Associate and faculty members involved in research with Aero students on program planning, thesis requirements and research specialty areas. The course is to be given to each input during second quarter on board.

AE 0110 REVIEW OF STATICS (4-4). A six-week course to review the principles of statics of particles, rigid bodies, and trusses; elementary vector arithmetic; properties of areas and volumes; beam shear and bending moment.

AE 0610 ANALOG COMPUTERS (0-2). A six-week course covering the theory and operation of analog computers, operational amplifiers and analog circuitry, algebraic operations, integration, time scaling and amplitude scaling. Typical applications in Aeronautics.

AE 0810 THESIS RESEARCH (0-0) Every student conducting thesis research will enroll in this course.

Upper Division Courses

AE 2021 AERO-STRUCTURES I (3-2). Development of concepts of two and three dimensional stress and strain including equilibrium, compatibility and stress-strain relationships. Solution methods are developed for bending stress, shear stress and deflections in symmetric, unsymmetric and box beam structures.

AE 2022 AERO-STRUCTURES II (3-2). A continuation of study of basic aircraft structural analysis including energy methods, indeterminate structures, torsion of solid and built-up beams and stability of columns and beam-columns. PREREQUISITE: AE 2021.

AE 2031 VEHICLE AERODYNAMICS I (3-2). Model atmospheres; defined airspeeds and altitudes; aircraft performance including climb, range, endurance, energy management, take-off and landing.

AE 2032 VEHICLE AERODYNAMICS II (3-2). Elements of two-dimensional flow, thin airfoil theory, finite wing theory, static aeroelastic effects on wing loads.

AE 2041 BASIC FLUID MECHANICS (3-2). Properties of fluids, fluid statics, dimensional analysis and dynamic similarity; principles of continuity, energy, and momentum; losses in internal flow systems, laminar and turbulent flow regimes; flow measurement; introduction to boundary layers, pressure and friction drag.

AE 2042 ENGINEERING THERMODYNAMICS (3-2). Equations of state, properties of pure substances, property relations; first and second laws of thermodynamics, entropy, irreversibility, availability; nonreactive mixtures; power cycle analysis.

AE 2801 INTRODUCTION TO AERO-LABORATORIES (0-3). An introduction to modern experimental techniques and instrumentation. Lectures, demonstrations and simple experiments in the use of sensing devices, signal processing, readout and recording devices. Evaluation of errors, data reduction and analysis, report writing. Familiarization with aeronautical engineering facilities.

Upper Division or Graduate Courses
(Note section on general rerequisite requirements)

AE 3015 ENGINEERING DYNAMICS (3-2). Fundamental physical concepts; dynamics of particles and of systems of particles; concepts of work-energy and impulse-momentum; rigid body dynamics; the inertia tensor and Euler's equations. Introduction to vibration theory and to the analytical, Lagrangian formulation of dynamics.

AE 3033 VEHICLE AERODYNAMICS III (3-2). Principles of longitudinal, lateral and directional static and dynamic stability and control of aircraft.

AE 3043 FUNDAMENTAL CONCEPTS OF GASDYNAMICS (3-2). The dynamics and thermodynamics of compressible fluid flow. One-dimensional isentropic flow, normal and oblique shocks, Prandtl-Myer flow; Fanno and Rayleigh flows. Applications to aeronautics.

AE 3321 FLIGHT EVALUATION TECHNIQUES I (3-2). Quantitative and qualitative techniques for the evaluation of aircraft performance in flight. Aircraft data acquistion systems. Normalizing and standardizing of flight test data. Pilot rating scales. Effects of design parameters on performance. Laboratory flights in Departmental aircraft.

AE 3322 FLIGHT EVALUATION TECHNIQUES II (3-2). Techniques for the evaluation of aircraft static and dynamic stability and control characteristics. Flying qualities and handling qualities. Variation of stability parameters. Application of specifications to flight evaluations. Maneuvering flight. Laboratory flights in Department aircraft.

AE 3801 AERONAUTICAL DATA SYSTEMS (3-2). Equipment and procedures to be used in flight and aeronautical laboratory measurement, recording, and analysis of parameters. Advanced application of transducers, amplifiers, signal processors and recording devices. Statistical analysis of processed data.

AE 3811 SOLID MECHANICS LABORATORY (0-3). Selected experiments in the areas of aero-structures and dynamics. PREREQUISITES: AE 2022, AE 3015 concurrently.

AE 3851 GASDYNAMICS LABORATORY (0-3). Selected experiments in the areas of subsonic and supersonic compressible fluid flow. PREREQUISITES: AE 2032, 3043.

AE 3900 SPECIAL TOPICS IN AERONAUTICS (2-0 to 5-0). Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

Graduate Courses
(Note section on general prerequisite requirements)

AE4101 FLIGHT VEHICLE STRUCTURAL ANALYSIS I (3-2). Theory of plate and shell structures as applied to aircraft and spacecraft. Rectangular and circular plates; composite and stiffened plates; vibration, stability, and large deflection of plates; membrane theory of shells of revolution; general theory of shells of revolution; vibration, stability, and large deflections of shells of revolution.

AE 4102 FLIGHT VEHICLE STRUCTURAL ANALYSIS II (3-2). Finite element stiffness method as applied to aircraft and spacecraft. Energy theorems; stiffness matrices for structural elements; refined and isoparametric elements; matrix displacement method; analysis of substructures; current aerospace computer programs; structural modeling techniques; dynamics and stability of elastic systems; synthesis and optimization.

AE 4131 SOLID MECHANICS FOR AERONAUTICAL ENGINEERS I (3-2). Theory of elasticity applied to aircraft problems beginning with the formulation of the three-dimensional field equations and continuing with engineering solutions by means of classical analytical methods, approximate energy methods, photoelastic methods and numerical methods.

AE 4132 SOLID MECHANICS FOR AERONAUTICAL ENGINEERS II (3-2). Further development of elasticity theory to provide the application of stress analysis methods in assessing ultimate structural integrity of aircraft structures through theories of failure, fracture mechanics, fatigue and buckling. PREREQUISITE: AE 4131.

AE 4139 SPECIAL TOPICS IN SOLID MECHANICS (4-0). Selected advanced coverage of topics in solid mechanics including: plasticity, viscoelasticity, general stability, thermoelasticity, nonlinear elasticity, wave propagation, etc. May be repeated for credit if taken with different topics. PREREQUISITE: Consent of Department Chairman.

AE 4271 DESIGN PROBLEMS IN AERONAUTICS I (3-3). A complex engineering problem in the field of flight vehicles is presented for solution by systems-oriented methods, with the primary purpose of developing basic understanding for the design process. Integration of various disciplines, evaluation of airworthiness requirements, real-life complexities, and team work with clearly assigned responsibilities are emphasized. PREREQUISITE: Consent of Department Chairman.

AE 4272 DESIGN PROBLEMS IN AERONAUTICS II (3-3). Continuation of AE 4271.

AE 4301 FLIGHT VEHICLE RESPONSE (3-2). Topics in stability and control of flight vehicles including the effects of cross-coupling and aeroelasticity; state space formulation and solutions, controllability and observability.

AE 4302 LOW SPEED VEHICLE AERODYNAMICS (3-2). Topics in the performance, stability and control characteristics of low-speed aircraft; ground effect phenomena, VTOL, STOL and rotary wing aircraft, air cushion and compound vehicles.

AE 4316 STRUCTURAL DYNAMICS (3-2). Response of discrete and continuous elastic structures to transient loads and to steady oscillatory loads utilizing matrix methods. Manual and computer methods of calculation. An introduction to random vibrations may also be offered as an optional topic at the discretion of the instructor.

AE 4317 AEROELASTICITY (4-0). Static aeroelasticity problems in aircraft; non-stationary airfoil theory; strip and lifting surface concepts. Application to the flutter problem. Transient loads, gusts, buffet, and stall flutter.

AE 4341 GUIDANCE AND CONTROL FOR AEROSPACE SYSTEMS I (3-2). Fundamental characteristics of feedback systems; time and frequency domain analysis of linear systems; state variable analysis; stability determination; root locus and frequency response diagrams; analog computer simulation of control systems.

AE 4342 GUIDANCE AND CONTROL FOR AEROSPACE SYSTEMS II (3-2). State vector solutions for continuous and sampled data systems; introduction to nonlinear systems; Liapunov's second method; optimal and modal control concepts; random processes; human pilot modeling. PREREQUISITE: AE 4341.

AE 4401 ADVANCED THERMODYNAMICS (3-2). Reactive mixtures, kinetic theory, transport phenomena, quantum statistics; partition functions, thermodynamic properties.

AE 4402 COMBUSTION (3-2). Reacting gas mixtures, combustion temperature, chemical kinetics, combustion generated pollutants, detonations and deflagrations, laminar and turbulent flame theories and experimental results, flame stabilization, gas turbine combustor design. PREREQUISITE: AE 4401.

AE 4431 AEROTHERMODYNAMICS OF TURBOMACHINES (4-0). Application of fundamental laws of fluid dynamics and thermodynamics to the analysis of flows in turbomachines. AE 4831 concurrently.

AE 4432 ADVANCED THEORY OF TURBOMACHINES (4-0). Advanced theory and methods for design and performance prediction of turbomachines. PREREQUISITE: AE 4431, AE 4832 concurrently.

AE 4451 AIRCRAFT AND MISSILE PROPULSION I (3-2). Description of various propulsion methods: rockets, ramjets, gas turbines, and, briefly, space propulsion. Includes parameters that specify system performance, information on current state of art and impact of trends in propulsion technology. Thrust and drag. Discussion of components: inlets, combustors, nozzles. Creative thinking is encouraged by discussion of novel propulsion schemes, stressing relationship to gas dynamics, mechanics and aerothermodynamics.

AE 4452 AIRCRAFT AND MISSILE PROPULSION II (3-2). Using the knowledge gained in AE 4451, the components are assembled, conceptually to form ramjets, turbofans, etc., for which performance (SFC, thrust) is predicted. Several missions (e.g., fighter aircraft, air-to-air missile) are defined and the best propulsion system is selected for each application. PREREQUISITE: AE 4451.

AE 4501 ADVANCED GASDYNAMICS (4-0). Similarity and perturbation methods applied to two-dimensional subsonic, supersonic and transonic flow. Shock wave interactions and reflections with reference to the hodograph plane. Method of characteristics: unsteady, and supersonic. Influence of viscosity and heat conduction on gas dynamics. Some computer problems in gas dynamics.

AE 4502 HYPERSONIC FLOW AND REAL GAS EFFECTS (3-2). Real gas effects will be studied (dissociation, ionization) with reference to problems such as Couette flow, the wavy wall, and Prandtl-Meyer flow. Some hypersonic flow with emphasis on small perturbation analysis, similarity solutions and Newtonian flow. PREREQUISITE: AE 4501.

AE 4503 AERODYNAMICS OF WINGS AND BODIES (3-2). Study of three-dimensional wings and bodies in subsonic and supersonic flow. Slender body theory and flow reversal theorems. Singular perturbation problems and unsteady flow with some computer problems. PREREQUISITE: AE 4501.

AE 4504 MAGNETOFLUIDDYNAMICS (3-2). Magnetohydrodynamic flows. Advanced energy conversion and propulsion systems which employ magneto/electrofluiddynamic principles. Definition and review of pertinent physical concepts. Current and future applications.

AE 4511 BOUNDARY LAYER THEORY (4-0). Some exact solutions of the Navier-Stokes equations. Boundary layer concept and equations, momentum and energy integrals, stability and transition. Fundamentals of turbulent flow; laminar and turbulent boundary layers with arbitrary pressure gradients. Techniques of solution.

AE 4512 CONVECTIVE HEAT AND MASS TRANSFER (4-0). Convective heat and mass transfer in ducts and from exposed surfaces; laminar and turbulent flows. Analytic techniques, integral and numerical methods, experimental correlations. Effects of variations in thermophysical properties. Combined heat and mass transfer. PREREQUISITE: AE 4511.

AE 4632 COMPUTER METHODS IN AERONAUTICS (3-2). Computer solutions of ordinary and partial differential equations for aerospace structures, gas dynamics, flight mechanics, dynamics and heat transfer problems. Equilibrium, eigenvalue and propagation problems in discrete and continuous systems. Introduction to computer design, computer graphics, hybrid computers, and systems simulation. PREREQUISITE: MA 3232.

AE 4831 TURBOMACHINERY LABORATORY I (0-3). Measurements of the performance of turbomachines. PREREQUISITE: AE 4431 concurrently.

AE 4832 TURBOMACHINERY LABORATORY II (0-3). Detailed investigations of stationary and rotating components of turbomachines. PREREQUISITE: AE 4432 concurrently.

AE 4900 ADVANCED STUDY IN AERONAUTICS (2-0 to 5-0). Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Chairman.

AVIATION SAFETY PROGRAMS

JAMES CHRISTIAN NIELSEN, Associate Professor of Aeronautical Engr. and Safety; Director (1966)*; B.S.A.E., Univ. of Washington, 1950; M.S.A.E., 1957.

CLYDE HENRY TUOMELA, Captain, U. S. Navy; Military Director (1974); B. S., Stanford Univ., 1959; M.S., George Washington Univ., 1972; War College, 1972.

RUSSELL BRANSON BOMBERGER, Associate Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; L1.B., LaSalle Univ., 1968; J.D., 1969; M.A., Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

CRAIG MERRILL BRADBURY, Commander, U. S. Navy, Instructor in Aircraft Accident Prevention and Crash Investigation (1969); B.S., Naval Postgraduate School, 1963.

JOHN JOSEPH BRANSON, JR., Commander, U. S. Navy, Assistant Professor in Aeronautical Engr. and Safety (1971); B.S., Naval Academy, 1950; B.S.A.E., Naval Postgraduate School, 1957; M.S., 1958.

JOHN PAUL CRESS, Captain, U. S. Marine Corps, Instructor in Aeronautical Engineering and Safety (1972); B.A.A.E., Ohio State Univ., 1967.

EDWARD JOHN KENNEDY, Associate Professor of Aviation Physiology (1972); M.D., Univ. of Iowa College of Medicine, 1962.

LESTER CHARLES WIBLE, Assistant Professor of Aviation Accident Prevention and Crash Investigation (1965); B.S., Naval Academy, 1945.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

SURVEY OF AVIATION SAFETY

A short Aviation Safety Officers course is offered eleven times per year on a temporary additional duty basis for those commands needing a trained Aviation Safety Officer. The course, entitled Survey of Aviation Safety (SAS), prepares aviation safety officers at the squadron level to assist commanding officers in conducting an aggressive accident prevention program. When the ASO completes this course he will be able to organize and administer an accident prevention program at the squadron/air wing level as defined in OPNAVINST 3750.14 and 5100.8.

This 4 week SAS course consists of approximately 138 classroom hours of safety program management, including mishap prevention techniques, invoking practical operational aerodynamics and aircraft structures, mishap investigation and reporting, psychology, aviation law, and aviation physiology. Prior completion of college level courses in algebra and/or physics is highly desirable. One class field trip to conduct an aviation safety survey is included. In order to more efficiently serve all, classes are tailored to generic aircraft communities (Jet, Recip/Turbo-Prop, and Helicopter). No members of any community are restricted from attending any desired class; however, attendees must be aware that material at each session will be most germane to the needs of the specific group.

Designated naval aviators and naval flight officers of the Navy and Marine Corps of the rank of Lieutenant, USN, and Captain, USMC, and above are eligible to attend. Exceptions must be approved by Type Commanders, or CMC, as appropriate. Details of quota control and class schedules are defined in CNETNOTICE 1520.

RESIDENT COURSES

Officers regularly enrolled in other curricula at the Postgraduate School may qualify as Aviation Safety Officers by completion of the program requirements; AO 2301 or 2303, AO 2302, AO 2352, AO 2381. Substitutions for some of these courses may be made by taking equivalent courses in other departments upon approval by the Director of Aviation Safety. Examples: AO 2301 or AO 2303 may be replaced by upper division or graduate courses in Aeronautical Engineering covering similar topics. AO 2352 may be replaced by upper division or graduate courses in Psychology covering similar topics.

AVIATION

Upper Division Courses

AO 2301 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Mathematics through college algebra and geometry; physics through mechanics and heat. (This course is for students in the BA program or other non-technical programs).

AO 2302 AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (3-2). This course consists of (a) a study of existing Navy Department instructions covering all aspects of accident investigation, prevention, and reporting procedures; (b) methods and techniques of accident investigation; (c) implementation and use of a prevention program; and (d) physiological factors of flight. PREREQUISITE: AO 2301, AO 2303, or equivalent (may be taken concurrently).

AO 2303 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Mathematics through calculus, courses in thermodynamics, statics and dynamics. (This course is for students of the BS program or other technical programs).

AO 2360 AVIATION PHYSIOLOGY (2-0). A review of basic fundamentals of physiology with emphasis on the circulatory respiratory systems, vision and hearing, with the objective of understanding the principles associated with the physiological stresses encountered in aviation. The role of the squadron flight surgeon in the squadron training program and his duties in aviation accident prevention, investigation and reporting.

PSYCHOLOGY

Upper Division Course

AO 2352 PSYCHOLOGY IN ACCIDENT PREVENTION AND INVESTIGATION (4-0). A study of logical and psychological principles and practices useful in developing mental efficiency and emotional strength, designed especially for the Aviation Safety Officer. Topics include rational processes, emotional processes, and basic transactional analysis.

LAW

Upper Division Course

AO 2381 AVIATION LAW (1-0). A study of the privileged status of the Aircraft Accident Investigation designed especially for the Aviation Safety Officer Program.

Control console for the turbojet test cell in the Jet Engine Laboratory

COMPUTER SCIENCE GROUP

GERALD LEONARD BARKSDALE, JR., Assistant Professor of Computer Science and Mathematics; Chairman (1967)*; B.S.E.E., Rice Univ., 1965; M.S., 1966, M.S., Univ. of Wisconsin, 1972.

BELTON EARL ALLEN, Lieutenant, U. S. Naval Reserve; Instructor in Computer Science and Mathematics (1974); B.A., Rice Univ., 1969; M.S., Univ. of Houston, 1971.

RAYMOND HARVEY BRUBAKER, JR., Lieutenant (junior grade), U. S. Naval Reserve; Assistant Professor of Computer Science and Mathematics (1971); B.S., Univ. of California at Los Angeles, 1971; M.S., 1971.

LAWRENCE LEO DANFORTH, Lieutenant Commander, U. S. Navy; Instructor in Computer Science and Mathematics (1973); B.S., Univ. of California at Berkeley, 1963; M.S., Naval Postgraduate School, 1972.

GREGORY DEAN GIBBONS, Assistant Professor of Computer Science and Mathematics (1970); B. A., Univ. of California at Santa Barbara, 1963; Ph.D., Carnegie Mellon Univ., 1972.

BENNETT ALLAN GOLD, Lieutenant Commander, U. S. Navy; Instructor in Computer Science and Mathematics (1973); B.A., Stanford Univ., 1960; M.S., Naval Postgraduate School, 1970.

RICHARD CARL HANSEN, Lieutenant Commander, U. S. Navy; Instructor in Computer Science and Mathematics (1974); B.A., Univ. of California at Los Angeles, 1961; M.S., Naval Postgraduate School, 1970.

GARY ARLEN KILDALL, Assistant Professor of Computer Science and Mathematics (1969); B.S., Univ. of Washington, 1967; M.S., 1968; Ph.D., 1972.

UNO ROBERT KODRES, Associate Professor of Mathematics and Computer Science (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

VICTOR MICHAEL POWERS, Assistant Professor of Electrical Engineering and Computer Science (1970); B.S.E.E., Univ. of Michigan, 1963; M.S., 1964; Ph.D., 1970.

THOMAS GORDON PRICE, JR., Lieutenant (junior grade), U. S. Naval Reserve; Instructor in Electrical Engineering and Computer Science, (1971); B.S.E.E., Univ. of Texas, 1968; M.S., Stanford Univ., 1970.

GARY MICHAEL RAETZ, Ensign, U. S. Navy; Instructor in Computer Science and Mathematics (1973); B. S., Portland State Univ., 1972; M.S., Naval Postgraduate School, 1973.

GEORGE ANTHONY RAHE, Associate Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

DAVID WALTER ROBINSON, Lieutenant, U. S. Navy; Instructor in Computer Science and Mathematics (1973); B.S., U. S. Naval Academy, 1965; M.S., Naval Postgraduate School, 1973.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEGREE REQUIREMENTS

BACHELOR OF SCIENCE WITH MAJOR IN COMPUTER SCIENCE

The requirements for a Bachelor of Science degree with major in Computer Science will include at least 10 hours in upper division mathematics, 6 hours in probability and statistics, 18 hours in computer science, and 4 hours in management.

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. To obtain the Master of Science degree in Computer Science, the students must have satisfied the requirements for the Bachelor of Science degree in Computer Science.

2. In addition, the student must successfully complete a minimum of 40 quarter hours of graduate credit including:

	Minimum Hours
Computer Science	20
Mathematics	6
Operations Analysis or Electrical Engineering	6

3. In addition, the student must successfully complete an acceptable thesis.

LABORATORY FACILITIES

The Computer Science Group maintains a Computer Laboratory made up of an interconnected computer complex consisting of a medium size digital computer, two high performance interactive graphic computer systems, and a general purpose hybrid/analog computer. This complex supports a wide range of instruction and research in digital and hybrid computation and simulation. The facility is available school-wide for "hand-on" use in instructional and research programs.

The Computer Science Group also maintains laboratory facilities supporting research in microprocessing, emulation, signal processing, interactive graphics, and computer networking. In addition, computational resources of the W. R. Church Computer Center provide support for time-sharing and batch processing.

COMPUTER SCIENCE

CS 0001 SEMINAR (0-1). Special lectures; guest lectures; discussion of student thesis research faculty research projects. PREREQUISITE: None.

CS 0110 FORTRAN PROGRAMMING (3-0). The basic elements of FORTRAN are covered. Practical application of the principles is afforded by means of a series of problems of increasing difficulty.

CS 0113 COBOL PROGRAMMING (3-0). The basic elements of COBOL are covered. Practical application of principles is afforded by means of a series of problems of increasing difficulty. Television lectures.

CS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Course

CS 1500 INTRODUCTION TO CALCULATION AND PROGRAMMING (2-1). Introduction to basic concepts of programming and calculation. Introduction to the Hewlett-Packard Model 9810A programmable calculator and associated peripheral equipment. CO-REQUISITE: MA 2129.

Upper Division Courses

CS 2100 INTRODUCTION TO COMPUTERS AND FORTRAN PROGRAMMING (4-0). Characteristics of general purpose digital computers. Algorithmic approach to problem solving, considering numerical and non-numerical examples. Basics of machine language programming. Fundamentals of FORTRAN programming. Functions of compilers and assemblers. PREREQUISITE: None.

CS 2103 INTRODUCTION TO COMPUTERS AND COBOL PROGRAMMING (4-0). History of computers. Characteristics of digital computers and peripheral devices. Basics of machine language programming. Problem analysis and programming in COBOL. Problems selected from the area of business data processing. PREREQUISITE: None.

CS 2105 SURVEY OF COMPUTERS AND PROGRAMMING (4-0). A general appreciation of computer history, computer system organization, computer applications and computer management. Flowcharting and coding in an algorithmic language. Not recommended for anyone intending to take further courses in computer science. PREREQUISITE: None.

CS 2110 INTRODUCTION TO COMPUTERS AND PROGRAMMING FOR COMPUTER SCIENCE MAJORS (3-2). Characteristics of general purpose digital computers. Algorithmic approach to problem solving, considering numerical and non-numerical examples. Basics of machine language and assembly language programming, emphasizing interactions with peripheral devices. FORTRAN programming. Characteristics of compilers, assemblers, and interpreters. Intended to provide more intensive coverage than CS 2100. PREREQUISITE: CS 0110 or the equivalent.

CS 2501 INTRODUCTION TO COMPUTER SYSTEMS (2-0). Hardware and software components of large computer systems. Fundamentals of I/O operations, operating systems, interactive computation, job control languages, and procedure oriented languages. PREREQUISITE: CS 1500.

CS 2600 INTRODUCTORY COMPUTING AND COMPUTER SCIENCE FOR OPERATIONS ANALYSTS (2-0). An introduction to computer problem solving methods for students in the Operations Research curriculum. Topics include subprograms, numerical error control and numerical methods and program organization and debugging. Emphasis is placed on actual computer programming experience with 5-7 operations research related projects of increasing difficulty. Classroom examples and assigned projects are drawn from first quarter Operations Research courses. PREREQUISITE: CS 0110 or experience in FORTRAN programming.

Upper Division or Graduate Courses

CS 3111 FUNDAMENTAL CONCEPTS IN STRUCTURAL PROGRAMMING LANGUAGES (4-0). An introduction to the significant features of programming languages. Formal definition of a language including specification of syntax and semantics. Characteristics of assemblers, compilers and interpreters. Properties of block structured languages, including scope of declarations, storage allocation and subroutines. Basic programming techniques, including string manipulation, list processing, bit manipulation and recursion. PREREQUISITE: Either CS 2100, CS 2103, CS 2110 or consent of the Instructor.

CS 3112 OPERATING SYSTEMS (4-0). Classical serial processing techniques, processor and Input-Output overlap. Multiprogramming, multiprocessing, stack-oriented processing. Addressing, indexing operations, storage allocation techniques. Time sharing, paging and task scheduling. Comparison of currently available large scale digital computer systems. PREREQUISITE: CS 2110 or CS 3111.

CS 3200 STRUCTURE OF DIGITAL COMPUTERS (4-0). Boolean algebra, combinational and sequential circuits, arithmetic units, memory units, input-output devices, computer organization and control, microprogramming. PREREQUISITES: CS 2110 or equivalent.

CS 3201 COMPUTER SYSTEMS (4-0). System design concepts in computer hardware-software combinations. Processes, processors and virtual memory. Dynamic relocation using base registers, paging and segmentation. System communications—memory, auxiliary storage and input/output. Memory, control and capability protection. Resource allocation mechanisms, policies and problems. File system organization. Analysis, simulation and measurement techniques and their application to computer system design. Concepts are presented in terms of the fundamental insight provided by considering timesharing systems. PREREQUISITES: CS 3200, CS 3112.

CS 3204 DATA COMMUNICATIONS (4-0). Quantitative study of communication processes with emphasis on digital communication. Concepts fundamental to the engineering of accurate, efficient communication links and systems. Elements of information theory. Communication channels and their capacity, encoding and decoding of data over noisy channels. Error detection and correction coding schemes and procedures. Techniques and devices for effective data transmission in computer-based systems. PREREQUISITES: CS 3200 or EE 2810, PS 3401.

CS 3300 INFORMATION STRUCTURES (3-0). Basic concepts of data. Linear lists, strings, arrays, and orthogonal lists. Representation of trees and graphs. Storage systems and structures, and storage allocation and collection. Symbol tables and searching techniques. Sorting (ordering) techniques. Formal specification of data structures, data structures in programming languages, and generalized data management. PREREQUISITE: CS 3111.

CS 3601 AUTOMATA AND FORMAL LANGUAGES (3-0). Logical networks, neural networks, finite automata, minimalization of automata, regular expressions, context-free languages and push-down automata, context-sensitive languages and linear bounded automata. Ambiguity in formal languages. PREREQUISITE: MA 2025 or equivalent.

CS 3800 DIRECTED STUDY IN COMPUTER SCIENCES (0-2 to 0-8). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the Instructor. Graded on Pass/Fail basis only.

Graduate Courses

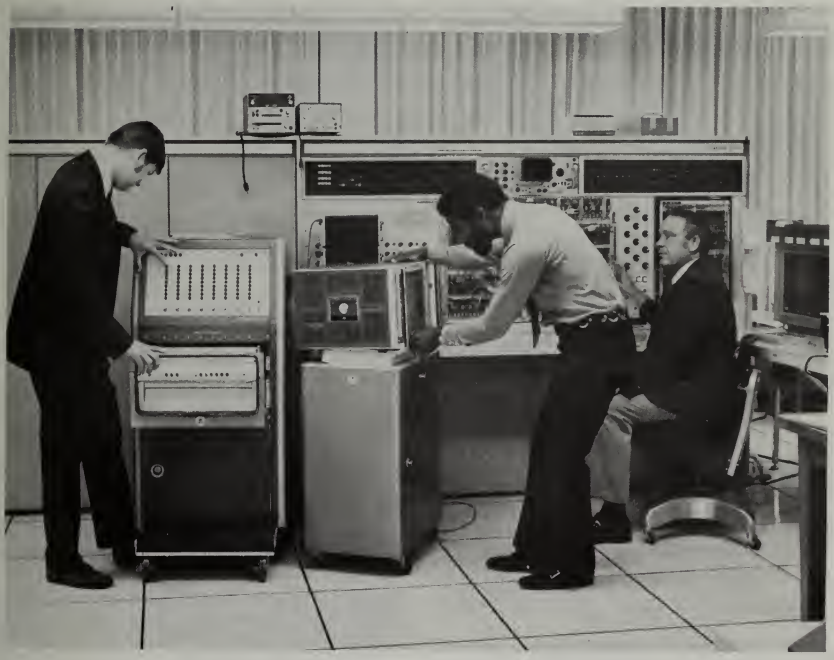
CS 4113 COMPILER DESIGN AND IMPLEMENTATION (3-2). Review of programming language structures, translation, loading, execution and storage allocation. Compilation of simple expressions and statements. Organization of a compiler: compile time and run-time symbol tables; lexical and syntax scanning; object code generation; diagnostic procedures; object code optimization; and general design techniques. Use of translator writing systems. Laboratory will emphasize practical application of compiler implementation techniques. PREREQUISITES: CS 2110 and CS 3111.

CS 4202 INTERACTIVE COMPUTATION SYSTEMS (3-2). A study of the man-computer interface and methods for computer-assisted problem solving. System facilities for man-computer interaction. Computer graphics, tranformations and graphics soft-

ware. Data structures, memory requirements, storage, file, and data management. Languages for man-computer interaction including graphics, command, problem-oriented, and special purpose languages. Laboratory work includes individual projects using interactive graphical consoles. PREREQUISITES: CS 3200, CS 3112, CS 3300 pre or corequisite, or consent of Instructor.

CS 4310 NON-NUMERICAL INFORMATION PROCESSING (4-0). Definition of heuristic versus algorithmic methods, rationale of heuristic approach, description of cognitive processes and approaches to mathematical invention. Objective of work in artificial intelligence, simulation of cognitive behavior and self-organizing systems. Heuristic programming techniques including the use of list-processing languages. Survey of examples from representative application areas. The mind-brain problem and the nature of intelligence. Class and individual projects to illustrate basic concepts. PREREQUISITE: CS 2110 or CS 3111.

CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0). Discussion of selected topics in the fields of current research in computer science. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.



Part of the computer facilities at the Postgraduate School

DEPARTMENT OF ELECTRICAL ENGINEERING

SYDNEY RICHARD PARKER, Professor of Electrical Engineering; Chairman (1966)*; B.E.E., City College of New York, 1944; M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

RICHARD WILLIAM ADLER, Assistant Professor of Electrical Engineering (1969); B.S., Pennsylvania State Univ., 1956; M.S., 1958; Ph.D., 1970.

ORESTES METHODIUS BAYCURA, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute of Technology, 1957, M.S., Univ. of Pittsburgh, 1959; D.Sc., 1963.

JOHN MILLER BOULDRY, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

STEPHEN BREIDA, Associate Professor of Electronics (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

ROBERT WARD BURTON, Lieutenant Colonel, U. S. Air Force; Associate Professor of Electrical Engineering (1973); B.S., U. S. Naval Academy, 1955; S.M. (E.E.), Massachusetts Institute of Technology, 1961; E.E., 1961; Ph.D., Harvard Univ., 1965.

SHU-GAR CHAN, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1954; M.S., Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

PAUL EUGENE COOPER, Professor of Electronics (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

MITCHELL LAVETTE COTTON, Associate Professor of Electronics (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

JOHN HENRY DUFFIN, Professor of Chemical Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

GERALD DEAN EWING, Associate Professor of Electrical Engineering (1963); B.S.E.E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E., Oregon State Univ., 1962; Ph.D., 1964.

ALEX GERBA, JR., Associate Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

DAVID BOYSEN HOISINGTON, Professor of Electronics (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

RAYMOND KENNETH HOUSTON, Professor of Electrical Engineering (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

STEPHEN JAUREGUI, JR., Associate Professor of Electrical Engineering (1971); B.S., Univ. of California at Berkeley, 1954; M.S., Naval Postgraduate School, 1960; Ph.D., 1962.

DONALD EVAN KIRK, Associate Professor of Electrical Engineering (1965); B.S., Worchester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1964.

CLARENCE FREDERICK KLAMM, JR., Professor of Electronics (1951); B.S., Washington Univ., 1943; M.S., 1948.

JEFFREY BRUCE KNORR, Assistant Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

GEORGE HEINEMANN MARMONT, Professor of Electronics (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

CARL ERNEST MENNEKEN, Distinguished Professor of Electronics (1942); B.S., Univ. of Florida, 1932; M.S., Univ. of Michigan, 1936.

ROBERT LEE MILLER, Professor of Electronics (1946); B.Ed., Illinois State Normal Univ., 1936; M.S. Univ. of Illinois, 1941.

GLEN ALLEN MYERS, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E. Stanford Univ., 1956; Ph.D., 1965.

HERBERT LEROY MYERS, Assistant Professor of Electrical Engineering (1951); B.S., Univ. of Southern California, 1951.

EUGENE JAMES NORMAND, Commander, United States Navy; Instructor in Electrical Engineering (1972); B.S., U. S. Naval Academy, 1957; M.S., Naval Postgraduate School, 1972.

JOHN EVERETT OHLSON, Associate Professor of Electrical Engineering (1971); B.S., Massachusetts Institute of Technology, 1962; M.S.E.E, Stanford Univ., 1963; Ph.D., 1967.

RUDOLF PANHOLZER, Associate Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule in Graz, Austria, 1953; D.Sc., 1961; M.S.E.E., Stanford Univ., 1956.

JOHN PATRICK POWERS, Assistant Professor of Electrical Engineering (1970); B.S.E.E., Tufts Univ., 1965; M.S., Stanford Univ., 1966; Ph.D., Univ. of California at Santa Barbara, 1970.

VICTOR MICHAEL POWERS, Assistant Professor of Electrical Engineering (1970); B.S.E.E., Univ. of Michigan, 1963; M.S., 1964; Ph.D., 1970.

THOMAS GORDON PRICE, JR., Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Electrical Engineering (1971); B.S.E.E., Univ. of Texas, 1968; M.S., Stanford Univ., 1970.

GEORGE ANTHONY RAHE, Associate Professor of Electrical Engineering (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

CHARLES HARRY ROTHAUGE, Professor of Electrical Engineering (1949); B.E., John Hopkins Univ., 1940; D.Eng., 1949.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D. Stanford Univ., 1964.

ABRAHAM SHEINGOLD, Distinguished Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

DONALD ALAN STENTZ, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S., Naval Postgraduate School, 1958.

ROBERT DENNY STRUM, Associate Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

TIEN-FAN TAO, Associate Professor of Electrical Engineering (1971); B.S., National Taiwan Univ., 1955; M.S., Univ. of Pennsylvania, 1958; Ph.D., Harvard Univ., 1963.

GEORGE JULIUS THALER, Distinguished Professor of Electrical Engineering (1951); B.E., Johns Hopkins Univ., 1940; D. Eng., 1947.

HAROLD ARTHUR TITUS, Professor of Electronics (1962); B.S., Kansas Univ., 1952; M.S. Stanford Univ., 1957; Ph.D., 1962.

JOHN BENJAMIN TURNER, JR., Associate Professor of Electronics (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

JOHN ROBERT WARD, Professor of Electrical Engineering (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

MILTON LUDELL WILCOX, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938; M.S., Univ. of Notre Dame, 1956.

EMERITUS FACULTY

WILLIAM MALCOM BAUER, Professor Emeritus (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S., Harvard Univ., 1929; D.Sc., 1940.

JESSE GERALD CHANEY, Professor Emeritus (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

EDWARD MARKHAM GARDNER, Professor Emeritus (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

GEORGE ROBERT GIET, Distinguished Professor Emeritus (1925); A.B., Columbia Univ., 1921; E.E., 1923.

RAYMOND PATRICK MURRAY, Associate Professor Emeritus (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

CHARLES BENJAMIN OLER, Professor Emeritus (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D. Eng., Johns Hopkins Univ., 1950.

WILLIAM CONLEY SMITH, Professor Emeritus (1946); B.S., Ohio Univ., 1935, M.S., 1939.

ALLEN EDGAR VIVELL, Dean Emeritus (1945); B.E., Johns Hopkins Univ., 1927; D. Eng., 1937.

RICHARD CARVEL HENSEN WHEELER, Professor Emeritus (1929); B.E., Johns Hopkins Univ., 1923; D. Eng., Rensselear Polytechnic Institute, 1926.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific academic requirement for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

1. Candidates for this degree must generally satisfy the following requirements while in residence at the Naval Postgraduate School, except in the case of candidates entering the school with advanced standing, when due allowance will be made for advanced transfer credits.

Discipline	Subject	Approximate Quarter Hours
Electrical Engineering	Fields and Circuits	13
	Electronic Devices and Circuits	15
	Communications Theory	4
	Electromagnetic Theory	6
	Energy Conversion	4
	Electronic Computers	4*
	Control Theory	4
		50
Mathematics	Calculus, vectors, matrices, series, differential equations and complex variables	12

*Courses in computer programming or theory with MA and CS prefixes may be substituted for electrical engineering courses in computers with approval of the Chairman of the Department.

2. An additional 8 quarter hours are to be taken in upper division courses in Electrical Engineering and 9 quarter hours in areas such as mechanics, dynamics, properties of matter, physical chemistry and thermodynamics. Minor departures from these requirements may be approved by the Department as long as the total number of hours in upper division courses is not reduced.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

1. A minimum of 40 quarter hours of graduate work beyond the requirements for the Bachelor of Science in Electrical Engineering degree shall be required for the degree of Master of Science in Electrical Engineering. The academic records of those students who do not complete the requirements for the Bachelor of Science in Electrical Engineering degree at the Naval Postgraduate School will be evaluated by the Department of Electrical Engineering to determine what additional undergraduate courses need to be taken to qualify for entry into the graduate program. Of the 40 quarter

hours a minimum of four courses, of at least 12 hours must be in the course sequence 4000-4999. At least 30 hours shall be required in Electrical Engineering subjects. An acceptable thesis must be presented. Approval of all programs must be obtained from the Chairman, Department of Electrical Engineering.

2. An acceptable thesis for the Engineer's Degree may be accepted as meeting the thesis requirements of the Master's Degree. However, the thesis requirement for the Master's Degree may be waived upon the approval of the Chairman of the Department under the following circumstances:

a. The student has been admitted to the Engineer's Degree or Doctor of Philosophy Degree program.

b. The student has completed four (4) 4000 level courses of a minimum of twelve (12) credits over and above the course requirements for the Master's Degree.

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in electrical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Electrical Engineering Department. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer. Normally this program is of three years' duration. Candidates for the Engineer's degree are selected during their second year in residence.

2. A minimum of 80 graduate course credits are required for the award of the Engineer's degree. Of these at least 30 hours are to be in courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman, Department of Electrical Engineering.

DOCTOR OF PHILOSOPHY

The Department of Electrical Engineering has an active program leading to the degree of Doctor of Philosophy. Areas of special strength in the department are signal processing, communication systems, electronic systems and devices, and control theory. Joint programs with other departments are possible. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

ELECTRICAL ENGINEERING LABORATORIES

The Electrical Engineering Department Laboratories have excellent facilities in almost all phases of modern electrical engineering. At present the laboratories are divided into Communications and Navigation, Microwaves and Antennas, Radar and Electronic Countermeasures, Signal Processing and Digital Systems, General Measurements, Solid State and Thin Films, Lasers, Control Systems, Sonar, Energy Conversion, and Bio-Engineering Laboratories. There are extensive service facilities including a calibration laboratory where a continuous program of calibration and maintenance of laboratory instruments is carried out.

In addition to the usual experimental and instructional type laboratories, status as a Naval facility enables the Department to utilize a number of modern systems as adjuncts to the laboratory. These include communications, radar, telemetry, sonar, countermeasures and navigational systems.

Students in the Department have access to the Computer Center (IBM/360 System) as well as the Computer Laboratory which is a school-wide direct access computer complex where each student may program and operate the computer system for the solution of his own problem. The facility includes a medium size digital computer, two high performance input-output display units, and a general purpose hybrid/analog computer; all integrated into a single system. These facilities support a wide range of research and instruction in digital and hybrid computation and simulation.

As a part of the laboratory facility, there are generous research spaces available for thesis students to conduct their research problems on an individual basis.

BIOENGINEERING/BIOMEDICAL STUDIES

The Department of Electrical Engineering has responsibility for the biology courses listed below. These courses together with certain ones offered by other departments can be included, as appropriate, in the curriculum of a student interested in a bioengineering/biomedical program as part of his studies toward a degree.

Upper Division or Graduate Courses

EE 3800 CELLULAR AND MOLECULAR BIOLOGY (4-0). The fundamental principles of the living cell covered from a biochemical and biophysical standpoint. The structure and role of macromolecules in the cell is studied; in particular DNA, RNA and their relations to cell function, to the synthesis of proteins, and to genetics. PREREQUISITES: CH 3401, and a course in probability and statistics.

EE 3801 HUMAN PHYSIOLOGY (5-0). A comprehensive course in mammalian physiology, emphasizing human functional aspects. PREREQUISITE: EE 3800.

EE 3820 BIOELECTRONIC INSTRUMENTATION (3-3). The application of electronic methods to biological and medical measurements is treated in depth. The special problems involved, such as design of electrodes and input amplifiers, and the conversion of data to meaningful parameters are studied. The laboratory includes actual measurement procedures, using living material. PREREQUISITES: EE 3801, EE 2103, EE 2212 or equivalent.

Graduate Courses

EE 4802 RADIATION BIOLOGY (5-0). Fundamental processes of energy transfer from radiation to living matter. Biochemical, physiological and genetic effects of radiation. Methods of experimental radiation biology. PREREQUISITES: EE 3801 and appropriate courses in nuclear physics.

EE 4840 NEURAL SIGNAL PROCESSING AND CONTROL (3-3). This course extends the coverage of neurophysiology beyond that given in EE 3801 Human Physiology. Lecture material describes the basic structure and performance of neural circuits especially those involved in sensory processing (visual, aural, etc.), those involved in multi-synaptic reflex arcs, including inhibitory action, and those involved in muscular control. Associative and integrative functions of the fore brain are studied. The laboratory part consists of experiments using living material and projects where basic models of neural processes would be set up and their performance measured, using real time computer processing as appropriate. PREREQUISITES: EE 3801, EE 3802, EE 2103, EE 2212, CS 2100 or equivalent.

EE 4880 ADVANCED TOPICS IN HUMAN PHYSIOLOGY (4-0). Recent advances in the study of human physiological systems are presented. The areas covered include circulation and heart, renal function, metabolic interrelations, endocrine systems and their control, immunology, and recent research in neurophysiology and the special senses. PREREQUISITES: EE 3801, EE 4840.

EE 4890 COMPUTER MODELING OF BIOLOGICAL SYSTEMS (2-4). This is a seminar and project type course. Its exact content will vary with the interests of the instructors and students. However, examples of models of biological systems, as reported in the current literature, will be studied, and, as laboratory projects, one or more new models will be devised and analyzed, using computer techniques. PREREQUISITES: EE 3801, EE 4840, EE 4414 or equivalent. A stochastic modeling course such as OA 3704 is desirable.

COMPUTER SCIENCE

Computer Science is an interdisciplinary effort administered by the Computer Science Group. Course descriptions may be found under the Computer Science Group listings. Additional computer related courses are offered by the Electrical Engineering, Mathematics, and Operations Research and Administration Sciences Departments.

DEFENSE COMMUNICATIONS

Upper Division Course

CO 2111 DEFENSE COMMUNICATIONS ORGANIZATION AND PLANNING (3-2). Organization and functions of Department of Defense Communications Systems including command and Control functions. A study of the National Communications System, Defense Communications Systems, and the complete Naval communications organization, including the Naval Security Group. Integration of the various organizational systems is emphasized. The role of communications in the Naval Planning process is studied as well as an introduction to communications planning. Appropriate field trips are included. U. S. Citizenship and SECRET Clearance are required.

Upper Division or Graduate Course

CO 3112 INTEGRATED DEFENSE TELECOMMUNICATIONS SYSTEMS (3-2). Brief review of Defense Tactical and Strategic Integrated Telecommunications Systems followed by in depth analysis of technical and managerial problems associated with current and programmed automated telecommunications systems. Course entails field trips to telephone, satellite and automatic telecommunications switching centers in conjunction with seminars on current supportive telecommunication topics. PREREQUISITES: CO 2111, MN 3105, MN 3170, MN 3183. U. S. Citizenship and SECRET Clearance are required.

ELECTRICAL ENGINEERING

EE 0110 REVIEW OF BASIC ELECTRICAL CONCEPTS (5-0). Topics include the current-voltage relations in simple circuits, circuit laws and theorems, elementary AC circuit concepts, physical definitions of circuit constants and laws of electron motion. A six week refresher course.

EE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

EE 0951 SEMINAR (0-1). Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

Upper Division Courses

EE 2101 BASIC CIRCUIT THEORY (3-2). An introduction to electrical engineering circuit theory; the circuit concept and circuit elements; power and energy; Kirchoff's current and voltage laws; solutions of first-order and second-order circuits with various inputs and initial state conditions; time varying circuits and nonlinear circuits; state equations and trajectory. PREREQUISITE: Integral calculus and MA 2045 (may be concurrent).

EE 2102 CIRCUIT ANALYSIS (4-2). Solutions of network equations using basic Laplace transform; network functions, poles and zeros and natural frequencies; sinusoidal steady-state analysis; coupled circuits; network theorems and parameters. PREREQUISITE: EE 2101 or equivalent.

EE 2103 LINEAR SYSTEMS ANALYSIS (4-2). Fourier transform methods; convolution; state-variable fromulation and solution; signal flow graphs; simulation of linear systems on analog and digital computers. PREREQUISITES: EE 2102; differential equations; complex variable theory and FORTRAN (may be concurrent).

EE 2104 ELECTRICAL ENGINEERING FUNDAMENTALS I (3-2). The physical principles of electrical engineering are presented, followed by basic circuit analysis. Topics covered are power and response in electrical circuits including single phase and three phase systems. Electronic principles are introduced. Primarily for scientific and non-electrical engineering curricula. PREREQUISITES: MA 1100 (may be concurrent).

EE 2105 ELECTRICAL ENGINEERING FUNDAMENTALS II (4-2). Electronic devices and their models are considered. Amplifiers and principles of feedback leading to the system concept are presented. Magnetic circuits and electromagnetic to mechanical energy conversion principles are studied. The Laplace Transform and the transfer function concept are included. Primarily for scientific and non-electrical engineering curricula. PREREQUISITE: EE 2104.

EE 2106 ADVANCED REVIEW OF CIRCUITS, SIGNALS AND SYSTEMS (5-2). A comprehensive review of the principles of analysis applied to signals, circuits, and systems for students who have a proven background in electrical engineering. Topics include circuit formulations, network theorems (including two ports); review of sinusoidal steady-state and frequency response methods, Laplace transform methods, convolution, Fourier integral, state equations and matrix methods, stability, discrete time systems and computer techniques. PREREQUISITE: Consent of Instructor and an electrical engineering circuits background.

EE 2111 ELECTRICAL FUNDAMENTALS FOR AERONAUTICAL ENGINEERS (4-2). An intensive course covering the fundamentals of Electrical Engineering including both circuits and electronic devices for students in Aeronautical Engineering. PREREQUISITES: MA 2047, MA 3130, MA 3173 or equivalent.

EE 2112 ELECTRONIC CIRCUITS, DEVICES AND SYSTEMS (3-2). Kirchhoff's Laws, sinusoidal and exponential functions of time, the Laplace transform, sinusoidal steady state circuits, coupled circuits, elementary vacuum tube and semiconductor devices amplifiers, modulation, oscillators, transmission and delay lines, digital circuits, sensors, noise and interference. Primarily for students in the environmental sciences. PREREQUISITES: College Physics and MA 3132.

EE 2114 COMMUNICATION THEORY I (4-0). In this introductory course the following concepts and their mathematical formulations are presented: power spectral density; matched filters; sampling; pulse encoding methods; frequency and time multiplexing; amplitude, frequency and phase modulation. In addition, a comparison of modulation methods is presented. PREREQUISITES: EE 2103 and EE 2212 or equivalent.

EE 2211 ELECTRONICS ENGINEERING FUNDAMENTALS I (4-2). A general introduction to electronic devices and circuits; the electrical properties and charge flow mechanisms of semiconductor materials; properties of p-n junctions with emphasis on their role in diodes and bipolar transistors; application of diodes in circuits, static bipolar transistor models; MOS and junction FET's. PREREQUISITES: EE 2102 (may be concurrent) or equivalent.

EE 2212 ELECTRONIC ENGINEERING FUNDAMENTALS II (4-3). Topics include analysis of linear amplifiers; determination of device parameters; design of biasing circuits; multistage amplifiers; properties of common amplifier configurations; feedback amplifiers; tuned amplifiers; and power amplifiers. PREREQUISITE: EE 2211.

EE 2213 ADVANCED REVIEW OF ELECTRONIC ENGINEERING FUNDAMENTALS (4-3). Review of semiconductor devices and circuit configurations; linear amplifiers and their analysis; multistage amplifiers and frequency response; power amplifiers and distortion effects, feedback amplifiers; stability effects and oscillation. PREREQUISITES: Degree in EE and permission of Instructor.

EE 2216 PULSE AND DIGITAL CIRCUITS (4-3). The topics studied include basic waveform characteristics and shaping techniques, wide-band linear amplifiers, characteristics of electronic switching devices, clipping, clamping and switching circuits, multivibrator and trigger circuits, time-base generators, logic circuits, counting and timing circuits. PREREQUISITES: EE 2212 or equivalent.

EE 2217 COMMUNICATION CIRCUITS (4-3). Electronic circuits used for the transmission and reception of analog and digital signals. Topics include oscillators, modulators and demodulators, frequency converters, and special-purpose amplifiers. PREREQUISITES: EE 2216, EE 2114.

EE 2222 ELECTRONIC FUNDAMENTALS I (3-2). The first of a sequence for nonengineering curricula. An introduction to electronic devices, circuits and systems is followed by a consideration of basic concepts of electrical circuit analysis, electronic conduction and emission processes in electronic devices and operational properties of diodes and control devices. PREREQUISITE: A course in calculus.

EE 2223 ELECTRONIC FUNDAMENTALS II (3-3). A continuation of EE 2222. Included topics are linear amplifier analysis, feedback techniques, tuned amplifiers, power amplifiers, and electronic power supplies. PREREQUISITE: EE 2222.

EE 2224 COMMUNICATION AND DIGITAL ELECTRONICS (4-3). Frequency spectra for information transmission, oscillators, modulation and demodulation techniques, frequency conversion, pulse circuits and digital techniques, communication transmitters and receivers. PREREQUISITE: EE 2223.

EE 2311 PRINCIPLES OF ENERGY CONVERSION (3-2). An introduction to the principles of energy conversion. Topics presented are thermoelectric, thermionic, photovoltaic, electrochemical and electromagnetic methods of energy conversion. PREREQUISITES: EE 2102, EE 2211, or equivalent, permission of Instructor.

EE 2411 CONTROL SYSTEMS (3-3). Introduction to the analysis and design of linear feedback control systems by means of s-plane and frequency response methods. Analysis using state variables for continuous and discrete systems; design using frequency and time domain performance indices is discussed. Laboratory work includes simulation using analog and digital computers; testing and evaluation of physical systems. PREREQUISITES: EE 2103 and CS 2100 or their equivalent.

EE 2421 INTRODUCTION TO COMMUNICATIONS TECHNOLOGY (4-2). The first of a sequence of five courses designed for the Communications Management Specialist. An introduction is given to the basic elements of the communication system, followed by pertinent principles of electrical circuits and fundamentals of electronic devices. PREREQUISITE: A course in calculus.

EE 2422 COMMUNICATIONS SYSTEMS I (4-3). A continuation of EE 2421. The topics covered are: The general analog communications system with identification of subsystems; power conversion, oscillators, modulation and demodulation, special purpose circuits, elementary communication theory. PREREQUISITE: EE 2421.

EE 2423 COMMUNICATIONS SYSTEMS II (4-3). A study of digital communication systems. The general concepts of digital signalling are covered, followed by a consideration of elementary switching and shaping circuits, logical processing and logic circuits, the digital computer as a communication sub-system, and elementary digital-data transmission theory. PREREQUISITE: EE 2422.

EE 2424 SIGNAL TRANSMISSION SYSTEMS (4-2). This course covers the elements of electrical energy transmission as applied to communications. The principles of electromagnetic waves are presented, guided waves on transmission lines and waveguides are studied. The radiated field in space, antennas and propagation are covered, and a representative system, such as a satellite communications system is studied. PREREQUISITE: EE 2423 (may be concurrent).

EE 2621 INTRODUCTION TO FIELDS AND WAVES (4-0). Static field theory is developed and applied to boundary value problems. Time-varying Maxwell equations are developed and solutions to the wave equations are presented. Additional topics include skin effect, reflection of waves and radiation. PREREQUISITE: EE 2103 or equivalent.

EE 2622 ELECTROMAGNETIC ENGINEERING (3-1). A continuation of EE 2621. Topics include transmission lines, waveguides and cavity resonators. Applications are presented in the laboratory. PREREQUISITE: EE 2621 or equivalent.

EE 2623 ELECTROMAGNETIC THEORY REVIEW (4-1). A comprehensive review of basic electromagnetic theory intended for those students having previous education in this subject area. This course will provide accelerated coverage of those topics in the basic undergraduate sequence EE 2621/2622. Topics include experimental laws and Maxwell's equations. Maxwell's equations are applied to problems in electrostatics and magnetostatics, plane wave propagation, TEM lines and cavities, TE and TM modes in rectangular and circular waveguides and cavities and radiation

from elementary sources. Transient and state circuit properties of transmission lines are also covered. PREREQUISITES: Consent of Instructor; previous background in electromagnetic theory.

EE 2721 INTRODUCTION TO ELECTRONIC SYSTEMS (4-1). A first course in electronic systems for the Operational Systems Technology (ASW) curriculum. Emphasis is on functional aspects of linear and non-linear operations on continuous and discrete signals. Topics include feedback amplifiers, linear circuits, reactive elements, non-linear elements, electronic logic and computation, and input/output and memory devices. PREREQUISITE: Mathematics through calculus; CO-REQUISITE: MA 2129.

EE 2810 DIGITAL MACHINES (3-3). Basic principles of digital system design with emphasis upon the organization and programming of simple computers. Elements of Boolean algebra and logic design. Storage organization and control. Input-output data flow. Relation of machine logic to program design. Laboratory sessions are devoted to study of computer logical elements, processing, storage, and I/O units. PREREQUISITE: CS 2100.

Upper Division or Graduate Courses

EE 3111 AVIONIC SYSTEMS (4-2). A course designed to provide as much background as possible in avionic systems for aeronautical engineers. Topics included are: radar principles, avionic computers, laser and infrared devices, sonar, navigation systems, systems engineering. PREREQUISITE: EE 2111.

EE 3116 COMMUNICATION THEORY II(3-2). A continuation of EE 2114. The concept of information measure (entropy) is introduced and its significance for communication systems is discussed. Noise sources and their measurement are treated. Statistical methods for handling noise and random signals are presented, followed by a study of detection problems in radar and pulse transmission systems. Correlation functions and their applications to communication systems are introduced. PREREQUISITES: EE 2114; a course in probability and statistics.

EE 3215 MICROWAVE DEVICES (4-2). Electron tube and solid state microwave devices are studied. Klystrons, magnetrons, traveling wave tubes, microwave transistors, tunnel diodes, varactors, bulk effect, quantum electronic and other current devices are among those included. PREREQUISITES: EE 2212, EE 2622 (or their equivalent), PH 2641, or permission of Instructor.

EE 3263 INTEGRATED ELECTRONICS (3-3). Fabrication of bipolar and MOS ICs. Digital bipolar and MOS MSI and LSIs: multiplexers, decoders, memories, etc. Linear ICs: operational amplifiers, wave generators, phase locked loops, etc. Discussion of recent developments in ICs. PREREQUISITE: EE 2216.

EE 3311 ENERGY CONVERSION (3-2). A consideration and application of principles used in conversion of energy to the electric form. Devices utilizing these principles are analyzed and include thermoelectric, thermionic, electrochemical and others. A term paper based on library research in the energy conversion field is required. PREREQUISITES: EE 2102 or equivalent, EE 2211, permission of the Instructor.

EE 3312 ELECTROMAGNETIC MACHINES (3-4). The model oriented approach to the analysis of rating machines and amplifiers is utilized to obtain their dynamic and steady state characteristics. DC motors, generators and control machines are analyzed. PREREQUISITE: EE 2103 or equivalent.

EE 3413 FUNDAMENTALS OF AUTOMATIC CONTROL (3-3). A course in the fundamentals of automatic control theory and practice, primarily for nonelectrical engineering curricula. Topics include analysis and design of linear feedback control systems using frequency and time-domain techniques. Performance indices are discussed with application to the broad field of controls. Laboratory work includes computer simulation and test and evaluation of physical systems. PREREQUISITES: MA 3132 EE 2105 or equivalent, or permission of Instructor.

EE 3420 ENGINEERING FUNDAMENTALS OF ELECTRO OPTICS (3-1). An introduction to elements of electro-optic systems for engineering students. Elements such as lasers, light emitting diodes, infared sources and detectors are studied to characterize their operating parameters and limitations. The influence of other elements such as lens systems and properties of the propagation channel are also studied. PREREQUISITES: PH 2641 and EE 2212 or equivalent.

EE 3422 MODERN COMMUNICATIONS (3-2). A study of modern communications trends, with emphasis on theoretical study of current and proposed systems. The topics covered include multiplex systems, coding, and pseudo-random noise modulation systems. PREREQUISITE: EE 3116 or EE 4571.

EE 3425 COMMUNICATION SYSTEMS ANALYSIS (3-3). The final course in the Communications Management sequence. The objective is to look at the overall Communications System with particular attention to system aspects. Some of the subjects considered are: underlying communication theory, multiplexing methods, evaluation and selection of systems, modern trends in systems. PREREQUISITE: EE2424.

EE 3432 RADAR SYSTEMS (3-2). The principles of pulse radar systems are developed in classroom and laboratory exercises. Additional topics developed include the radar equation, doppler systems, automatic target-tracking systems, pulse compression, and multiple-unit steerable-array radars. PREREQUISITES: EE 2114, EE 3215, and EE 2622 or equivalent. This course is intended for students who do not have U. S. citizenship.

EE 3471 GUIDANCE AND NAVIGATION (3-2). A study of the systems involved in guidance and navigation. Topics include LORAN, OMEGA, NAVSAT, and inertial navigation systems. Various missiles and their guidance techniques are analyzed. PREREQUISITES: EE2411 and EE 3631.

EE 3483 PRINCIPLES OF ELECTRONIC WARFARE (unclassified) (2-2). This course in electronic warfare is intended for students who do not have U. S. Citizenship. Particular attention is paid to the problems encountered in jamming radar systems, to the intelligence information needed for jamming, and to anti-jamming features for radars. Other topics include intercept receivers, intercept probability, direction finding, confusion reflectors, and infared techniques. In the laboratory, basic principles are applied to jamming radar systems. PREREQUISITE: EE 3432 or EE 4433.

EE 3622 ELECTROMAGNETIC THEORY (3-1). Electromagnetic theorems and concepts are introduced. Plane, cylindrical and spherical wave functions are applied to problems of wave propagation, radiation, scattering and diffraction. Periodic and traveling wave structures are analyzed. PREREQUISITE: EE 2622 or equivalent.

EE 3631 ANTENNA ENGINEERING (4-2). An engineering course covering wire, array and aperature antennas for communications and radar systems. Basic propagation fundamentals are discussed. While essentially stressing engineering, this course applies field theory concepts developed in earlier courses to practical systems. PREREQUISITE: EE 2622 or equivalent.

EE 3641 ELECTROMAGNETIC COMPATIBILITY (3-1). An introduction to sources of electromagnetic interference and techniques for making electronic systems compatible. Receivers, transmitters and antennas are examined in communication, signal processing and radar systems. EMC tests and interference predictions are discussed. PREREQUISITES: EE 2217, EE 2622 or equivalent.

EE 3652 MICROWAVE CIRCUITS AND MEASUREMENTS (3-2). A continuation of EE 2622. Waveguides and cavities are discussed in more detail and perturbation theory is introduced. Other topics are selected from coupled lines, periodic circuits, strip line techniques, scattering parameters, and ferrites as well as topics from the current literature. Microwave measurement techniques will be presented in the laboratory. PREREQUISITE: EE 2622 or equivalent.

EE 3671 PROPAGATION (3-0). Properties of the earth and its atmosphere and their effect on radiowave propagation from ELF through millimeter wave-lengths. Topics include noise, scatter, coverage predictions and frequency selection. Use is made of engineering nomograms and computer methods. PREREQUISITE: EE 2622 or equivalent.

EE 3714 INTRODUCTION TO SIGNALS AND NOISE (4-1). A course in the analysis of signals and noise. The topics include signal and noise parameters, linear system response, modulation, sampling, correlation, and coding. The last week of the course requires participation in an ASW-related group project. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITES: EE 2721, PS 3411, MA 3139.

EE 3731 ELECTRONIC OCEANOGRAPHIC SYSTEMS AND PROCESSORS (4-2). A study of the electronic instrumentation systems used in making measurements below, on, and above the ocean air/water interface. These systems include basic electrical meters, spectrum analyzers, recorders, sonobuoys, sonar systems, STP recorders, velocimeter, precision navigational systems, and the digital computer and display systems used for processing data gathered. This course is primarily for students in the environmental sciences. PREREQUISITE: EE 2112.

EE 3812 SWITCHING THEORY AND LOGIC DESIGN (3-2). Models for logic elements and networks. Equivalence and machine minimization. Threshold logic. Synthesis of combinational and sequential networks. State assignment. Applications to digital machine design. Laboratory work is oriented around a project in logic network design. PREREQUISITE: EE 2810.

EE 3822 ENGINEERING APPLICATIONS OF COMPUTERS (3-3). Use of digital, analog, and hybrid computing machines in various application areas, e.g., systems design, parameter optimization, adaptive control, data acquisition and filtering, signal processing, biomedical instrumentation. Special techniques for real-time processing and simulation. Laboratory work is conducted in small groups and involves applications studies using the various types of computers. PREREQUISITE: EE 2810.

EE 3831 COMPUTER-AIDED NETWORK ANALYSIS AND DESIGN (3-2). Introduction to the application of computers in the analysis and design of passive and active networks. Topics included are: linear and non-linear networks; DC, AC, and transient analysis; sensitivity and optimization problems; off-line and on-line designs; theory and application of various general and special-purpose computer programs such as ECAP, CORNAP, CALAHAN, NASAP. Students will use these programs for their design problems. PREREQUISITES: EE 2211, EE 2103, or equivalent, and CS 2100 or equivalent.

Graduate Courses

EE 4121 ADVANCED NETWORK THEORY I (3-2). Topology. Circuit formulation, nonlinear modeling, and computer solutions. Circuit sensitivity models. Concepts and tests for passivity, activity, causality, and stability. Driving point synthesis. Transfer function properties and synthesis. PREREQUISITES: EE2103 or equivalent and EE 2211.

EE 4122 ADVANCED NETWORK THEORY II (3-2). Continuation of EE 4121. The approximation problem. N-port properties. N-port synthesis. The scattering matrix. PREREQUISITE: EE 4121.

EE 4123 ACTIVE NETWORK ANALYSIS AND SYNTHESIS (3-2). Active network synthesis with emphasis on active inductorless filters using controlled sources, operational amplifiers, gyrators ...etc. The approximation problem and sensitivity considerations are included. Emphasis is on the design of circuits using integrated components to meet design specification. PREREQUISITES: EE 2103 and EE 2212 or equivalent.

EE 4264 SOLID STATE ELECTRONIC DEVICES (3-2). Principles, operations, and applications of new and special purpose solid state elctronic devices: charge coupled devices (CCD) and their signal processing, memory and imaging applications, optoelectronic desensors, etc. Selected devices based on acoustooptic, electro-optic, ferroelectric and other effects. PREREQUISITES: EE 2212 or equivalent, PH 3741, or consent of Instructor.

EE 4410 MATHEMATICAL MODELS AND SIMULATION FOR CONTROL SYSTEMS (3-2). Modeling of linear and nonlinear systems. Modeling concepts and techniques. Philosophy of model studies. Verification of the model and its parameters. Design studies using computer models. PREREQUISITE: EE 2411.

EE 4412 NONLINEAR AND DISCRETE SYSTEMS (3-3). Techniques for the analysis of nonlinear and discrete systems. Phase plane and describing function analysis. Laboratory work includes analog and digital simulation. PREREQUISITE: EE 2411.

EE 4414 STOCHASTIC CONTROL THEORY (2-2). Statistical and probabilistic concepts are applied to the development of optimal methods for estimation, prediction, and identification. These methods are applied to the stochastic control problem. PREREQUISTIES: EE 2411 and PS 3411.

EE 4415 ALGEBRAIC METHODS IN CONTROL THEORY (3-0). This course treats advanced concepts in root-locus theory including graphical and analytical (algebraic) design of compensation. Extension is made to two-parameter analysis and design. The Mitrovic-Siljak relationships are developed, leading to the coefficient plane and parameter-plane methods. Stability analysis, adjustment, design and synthesis using parameter-plane methods are treated in detail. Extensions to multiparameter problems are discussed. PREREQUISITE: EE 2411.

EE 4416 TOPICS IN MODERN CONTROL THEORY (3-0). A course intended to acquaint the student with recent developments in control as found in the research publications of the profession. Topics are selected at the direction of the instructor and may include such subjects as Adaptive Systems, Digital and Hybrid Simulation, Finite State Automata, Learning Systems, Lyapunov Methods, Popov Stability, Sensitivity, etc. PREREQUISITE: Consent of the Instructor.

EE 4417 OPTIMAL CONTROL (4-0). The optimal control problem is treated using the calculus of variations. Pontryagin's maximum principle, and dynamic programming. Optimal pursuit-evasion strategies are considered. PREREQUISITE: EE 2411.

EE 4421 SYSTEMS CONCEPTS OF ELECTRO-OPTICS (3-1). For non-electrical engineering students. Systems concepts such as transfer function, bandwidth, signal-to-noise ratio will be introduced and applied to the design and analysis of typical electro-optic systems such as laser communications, forward-looking infared (FLIR) systems, laser radar, and low-light level television. Emphasis is on obtaining the overall system response and characteristics. PREREQUISITE: PH 3280.

EE 4422 ELECTRO-OPTIC SYSTEMS ENGINEERING (3-1). Analysis and design of electro-optic systems such as laser communications, optical information processing, infared imaging and detection systems, laser-aided guidance. Emphasis is on the design of systems to meet specifications and analysis of existing sys-

tems to understand the design philosophy. PREREQUISITES: EE 3420 or EE 4421.

EE 4433 ADVANCED RADAR SYSTEMS (3-2). The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression, frequency-modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurement of radar cross section of targets. PREREQUISITES: EE 2622 or equivalent, EE 3215, EE 4571 (may be concurrent), SECRET Cleance and U. S. Citizenship.

EE 4451 SONAR SYSTEMS ENGINEERING (3-2). A study of the theory and engineering practices pertaining to passive and active sonar systems. This study emphasizes the research and development of underwater acoustic surveillance systems. The objective of the course is to determine how the engineering design is conditioned by the characteristics of the transmission medium as well as the operational requirements. PREREQUISITES: PH 4454, EE 4571, EE 2212, U.S. Citizenship and SECRET Clearance.

EE 4452 UNDERWATER ACOUSTIC SYSTEMS ENGINEERING (4-2). A study of the theory and engineering principles of underwater acoustics, communications, surveillance, and navigational systems. Emphasis is placed on the principles and problems common to all underwater acoustic systems, and the design tradeoffs that are available to the engineer. The laboratory periods are used for making engineering tests on existing systems and designing, building, and testing a system or subsystem of the student's own design. PREREQUISITES: EE 4571, EE 2212.

EE 4461 ADVANCED SYSTEMS ENGINEERING (3-1). An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. The class will be expected to participate in a group project involving a feasibility study of a proposed new system. PREREQUISITES: EE4571, EE 2411.

EE 4473 MISSILE GUIDANCE SYSTEMS (3-1). Principles of inertial sensors and autonavigator systems. Radar and Infared trackers. Trajectory analysis. Steering logic. Proportional navigation. Pursuit-evasion strategy. Control of ballistic and aerodynamic vehicles. Navigation and guidance in space. Laboratory work is concerned with testing of components and evaluation by computer simulation of complete guidance system performance. PREREQUISITES: EE 4412, EE 4433 or equivalent, SECRET Clearance and U.S. Citizenship.

EE 4481 ELECTRONIC WARFARE TECHNIQUES AND SYSTEMS (3-3). Active and passive countermeasure techniques are considered, including signal representation, signal analysis, and signal interception. Important parameters of radar and communications systems are defined. Denial and deceptive jamming techniques are considered along with counter measure and counter counter-measure techniques. Signal intercept systems are treated. Acoustic, radio-frequency, infrared, and optical countermeasures are discussed PREREQUISITES: EE 4433, U.S. Citizenship and SECRET Clearance.

EE 4482 SIGNALS INTELLIGENCE (SIGINT) SYSTEMS ENGINEERING (2-2). This course covers airborne, shipboard, and ground based intercept and direction finding system techniques used against simple and sophisticated electromagnetic radiation systems. Among the topics covered are current state of the art for wideband and directional antennas, wideband RF preamplifiers, scanning and chirping receivers, displays, recorders, pattern recognizers and signal analysis devices. The laboratory periods are largely devoted to the specification and block diagram of systems to handle specified SIGINT tasks. PREREQUISITE: EE 4481 or permission of Instructor. U.S. Citizenship and SECRET Clearance are required.

EE 4541 DISCRETE SIGNAL PROCESSING (3-1). A course in the techniques and algorithms involved in the processing of discrete signals. Discrete fourier transforms, fast fourier transforms, and continuous processing using digital filter techniques. Included are the approximation problem of converting frequency domain specifications to discrete time algorithms, and synthesis techniques for filter realizations. Other topics include error analysis due to finite precision constants, quantization errors, noise generation due to finite precision arithmetic, limit cycles, and extension to two dimensional filters. Laboratory exercises include filter designs, realizations, and testing. PREREQUISITE: EE 2114 or equivalent.

EE 4571 STATISTICAL COMMUNICATION THEORY (3-2). This course is a more advanced sequel to EE 2114 than EE 3116. Basic concepts of information theory are introduced and their significance for communication systems is discussed. A study of noise sources and a mathematical treatment of noise and random signals based on statistical methods are presented. Transmission of such signals through linear and non-linear networks is analyzed. Statistical decision theory applications to signal detection and interpretation are illustrated by selected problems. PREREQUISITES: EE 2114 and PS 3411.

EE 4581 INFORMATION AND DETECTION THEORY (3-2). Classical detection and estimation. Application to detection of communications, radar, and sonar signals and estimation of signal parameters. Estimation and demodulation of continuous waveforms. Phase-locked loop theory and application to phase and frequency demodulation. Concept of information measure and channel capacity. Coding methods for error control in digital communications systems. PREREQUISITE: EE 4571.

EE 4591 COMMUNICATION SATELLITE SYSTEMS ENGINEERING (3-0). This course covers communication satellite systems including ground based, shipboard and airborne terminals as well as the satellite proper. Tradeoffs in orbits, modulation techniques, multipurpose systems, power sources, tie-in-techniques to standard communications including costs are covered. State of the art techniques in antennas, stabilizers, antennas, phase-locked-loops, and spread spectrum techniques are included. In addition, satellite tracking and siting problems are discussed. PREREQUISITES: EE 3631 or equivalent and EE 4571 (may be concurrent).

EE 4592 COMMUNICATION SATELLITE SYSTEMS ENGINEERING LAB (0-2). The laboratory will be devoted to specification and design of a COMSAT system to the block diagram level, including classified material, to augment EE 459I. PREREQUISITE: Simultaneous enrollment in EE 4591, U.S. Citizenship and SECRET Clearance.

EE 4623 ADVANCED ELECTROMAGNETIC THEORY (3-2). A study of topics in microwave theory including perturbational and variational techniques, coupled mode theory, microwave integrated circuits, ferrites and topics from the current literature. PREREQUISITES: EE 3622.

EE 4631 ANTENNA THEORY AND APPLICATIONS (3-2). Basic wire and aperture radiator principles and array theory are presented. Modern analysis and applications include numerical methods for wire antennas, Geometric Theory of Diffraction (GTD) for apertures and log-periodic arrays. Laboratory exercises demonstrate input impedance and radiation pattern measurements. PREREQUISITE: EE 3622.

EE 4716 SIGNAL PROCESSING SYSTEMS (4-1). A study of digital, analog, and hybrid signal processing systems for communication, echo ranging, and electronic surveillance. Examples from cur-

rent and proposed military systems will be analyzed. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: EE 3714.

EE 4823 ADVANCED DIGITAL COMPUTER SYSTEMS (3-1). A course intended to acquaint the student with recent developments in digital systems as found in the research publications. Topics are selected at the discretion of the instructor and may include such subjects as: machine organization, computer graphics, man-machine interfaces, design automation, parallel processing, etc. An individually planned laboratory program is directed toward an experimental project involving state-of-the-art utilization of computer hardware or software. PREREQUISITE: EE 3812.

EE 4900 SPECIAL TOPICS IN ELECTRICAL ENGINEERING (2-0 to 5-0). Supervised study in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. Graded on a pass/fail basis only. PREREQUISITE: Consent of the Department Chairman.

LCDR Kent H. Killam, USN, receiving the Chief of Naval Operations Communications award from Provost Jack R. Borsting

ENGINEERING ACOUSTICS

The academic character of programs in Engineering Acoustics is interdisciplinary, with courses drawn principally from the fields of electrical engineering and physics. Although broadly based, the emphasis is on those aspects of acoustics concerning propagation of sound in the oceans, on applications of underwater sound and on the electrical engineering of instrumentation for detection of underwater sounds.

The academic aspects of the programs are the responsibility of a committee, chaired by O.B. Wilson, Jr., Professor of Physics, with G.S. Sackman, Associate Professor of Electrical Engineering, as a member.

DEGREE REQUIREMENTS BACHELOR OF SCIENCE IN ENGINEERING ACOUSTICS

1. At the upper division level: 20 quarter-hours of physics, including at least 13 hours in physical acoustics, underwater acoustics and acoustics laboratory. 20 quarter-hours of electrical engineering, including courses in electronics, communication theory and sonar systems. Courses in mathematics which include partial differential equations and Fourier transforms. 6 quarter-hours of oceanography courses, including material on environmental parameters which affect underwater acoustics. A course in vibration and noise control.

2. A minimum QPR of 2.2 in physics and electrical engineering subjects.

3. Approval of each program by the Engineering Acoustics Academic Committee.

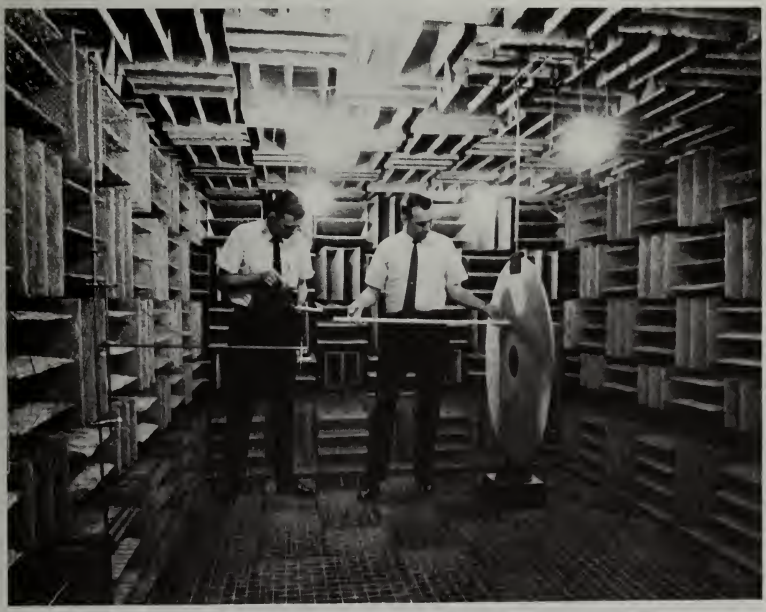
DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science. Credit requirement for the Master of Science degree must be met by courses in addition to those used to satisfy this requirement.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

4. Approval of each program by the Engineering Acoustics Academic Committee.



Acoustic measurements in the Anechoic Chamber of the Physics Department

On campus is Del Monte Lake shown here with the tower from Herrmann Hall in the background

ENGINEERING SCIENCE

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

1. The following are the minimum requirements for the degree Bachelor of Science in Engineering Science.

2. The degree in Engineering Science requires a minimum of 100 quarter hours in Engineering and Science of which at least 50 hours must be in the upper division level.

3. The following specific requirements must be met. Areas marked with an asterisk must include laboratory work:

	Approximate quarter Hrs.
a. Mathematics through calculus	17
b. Chemistry and Material Science*	15
c. Classical and modern Physics	16
d. Electrical Engineering including Electronics*	14
e. Mechanical Engineering including Mechanics and Thermodynamics	11
f. Probability and Statistics	3
g. Computers and Data Processing	4
h. Electives in Engineering and Science	20
	100

Electives will be chosen from courses in Mathematics, Chemistry or Physics, Electrical Engineering, Mechanical Engineering, Probability and Statistics, Computer Science, Oceanography, Meteorology, Operations Analysis.

Professor Thomas E. Cooper in mechanical engineering course

DEPARTMENT OF GOVERNMENT

BOYD FRANCIS HUFF, Professor of Government and History; Chairman, (1958)*; B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941, Ph.D., Univ. of California at Berkeley, 1955.

JOHN WILLIAM AMOS, II, Assistant Professor of Political Science (1970); B.A. Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972.

LOFTUR L. BJARNASON, Professor of Literature (1958); A.B., Univ. of Utah, 1934; A.M., Harvard Univ., 1939; Ph.D., Stanford Univ., 1951.

DAN EDWARD CALDWELL, Lieutenant, U. S. Naval Reserve; Instructor in Political Science (1971); A.B., Stanford Univ., 1970; M.A., Tufts Univ., 1971.

DONALD C. DANIEL, Lieutenant, U. S. Navy; Assistant Professor of Political Science; (1972); A.B., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

BARBARA BENNETT GABEL, Associate Professor of English (1967); A.B., Dickinson College, 1962; A.M., Peabody College, 1946; Ph.D., Univ. of North Carolina, 1954.

STEPHEN GOTTSCHALK, Associate Professor of History (1968); B.A., Occidental College, 1962; M.A., Univ. of California at Berkeley, 1963; Ph..D., 1968.

MARK WESTON JANIS, Lieutenant, U. S. Naval Reserve; Instructor in Political Science and History (1972); A.B., Princeton Univ., 1969; M.A., Oxford Univ., 1972.

EDWARD JOHN LAURANCE, Assistant Professor of Political Science (1972); B.S., U. S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

GEORGE ALFRED ROSS, JR., Lieutenant, U. S. Naval Reserve; Instructor in Political Science and History (1972); B.A., Dartmouth College, 1969; M.A., Univ. of Pennsylvania, 1970.

RUSSEL HENRY STOLFI, Associate Professor of History (1966); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

FRANK MICHAEL TETI, Associate Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; Ph.D., Syracuse Univ., 1966; M.P.A., 1972.

EMERITUS FACULTY

EMMETT FRANCIS O'NEIL, Professor Emeritus (1958); A.B., Harvard Univ., 1931; M.A., Univ. of Michigan, 1932; Ph.D., 1941.

**The year of joining the Post-graduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE BACHELOR OF ARTS WITH MAJOR IN GOVERNMENT (INTERNATIONAL RELATIONS)

For the award of the degree of Bachelor of Arts with major in Government (International Relations) a minimum of 44 hours of upper division courses in Government is required. Required courses include 12 hours in political theory, 12 hours in government, 8 hours in international relations, and 12 hours in comparative government. Course sequences and prerequisities shall be as prescribed by the Department of Government.

DEPARTMENTAL REQUIREMENT FOR THE DEGREE MASTER OF ARTS IN NAVAL INTELLIGENCE

1. The degree of Master of Arts in Naval Intelligence will be awarded upon completion of an interdisciplinary program carried out in accordance with the following requirements:

   a. A minimum of 44 quarter hours of graduate work, of which at least 12 quarter hours must be at the 4000 level. At least 20 hours must be in the area of national security affairs.

   b. Completion of graduate courses in at least three different academic disciplines, including a 4000 level course in at least two of these disciplines.

   c. Completion of an acceptable thesis in addition to the 44 quarter hours of course work.

   d. Approval of the program by the Chairman of the Department of Government.

LABORATORY FACILITY

The SPEECH LABORATORY is equipped with a closed circuit television and video-tape machine and has three cameras that provide a total of seven camera angles for speakers to be video-taped during classroom exercises. It is also equipped with a solid state sound system that is built into a lightweight adjustable lectern. A visual aids room adjoining the laboratory enables the speaker to use many types of audio-visual aids to support his speech.

Work is now being done with classes in conference dynamics which allows both instant replay and the compiling of data for future study and illustration in this area.

ENGLISH

EN 0110 READING IMPROVEMENT (0-5). A course to improve the student's reading speed and comprehension. Associated areas involved in reading are stressed, especially vocabulary-buildup, study habits, and composition.

EN 0111 REVIEW OF THE FUNDAMENTALS OF GRAMMAR AND MECHANICS (1-1). A special course designed to extend the student's command of the principles of standard English usage. Graded on Pass/fail basis only.

Lower Division Course

EN 1010 FUNDAMENTALS OF WRITING (4-0). The fundamentals of grammar and rhetoric with practice in writing.

Upper Division Courses

EN 2010 ADVANCED WRITING (3-0). Intensive writing experience with the grammatical and rhetorical principles underlying sound expository and argumentative prose. PREREQUISITE: Freshman English or permission of Chairman of Department.

EN 2020 REASONING AND RESEARCH WRITING (credit open). A study of the principles of symbolic logic and their application in developing clear thinking and effective presentation of ideas in written form. PREREQUISITE: College-level course in English composition, or permission of Department Chairman.

EN 2030 WRITING SEMINAR (credit open). A seminar in the art of clear thinking and lucid writing together with training in the preparation of research papers. PREREQUISITE: EN 2020 or equivalent.

EN 2239 DIRECTED STUDIES IN WRITING (Credit open). This course is designed to give editorial advice and assistance on an individual basis to students with writing projects in progress. PREREQUISITE: Permission of Chairman of Department. (Graduate students register for EN 3239.)

GOVERNMENT

GV 0010 SEMINAR IN NAVAL INTELLIGENCE (0-2). A continuing series of colloquium seminars in subjects bearing on Naval Intelligence. Seminars will be scheduled so as to phase in with the development of the curriculum.

GV 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

GV 1060 U. S. GOVERNMENT (4-0). American political institutions and processes, the Constitution, parties, interest groups, elections, and voting behavior, with special emphasis on current issues and problems.

GV 1368 AMERICAN LIFE AND INSTITUTIONS (3-0). American political institutions and the political, social, economic, and cultural aspects of American life. *Open only to Allied Officers.* Graded on Pass/Fail basis only.

Upper Division Courses

GV 2061 AMERICAN NATIONAL SECURITY POLICY (4-0). An institutional and functional analysis of the national and international factors which shape U. S. defense policy. Attention in the course is focused on two major areas: 1. the decision-making process, including the legislative-executive budgetary process, as well as the influence of bureaucratic politics and interest group articulation upon defense decisions; 2. the problems of strategic choice, including threat analysis, net assessment, deterrence theory, and limited war. *(Graduate students register for GV 3061.)*

GV 2160 COMPARATIVE GOVERNMENT (4-0). An analytical and comparative study of the form and functioning of the major types of contemporary government with emphasis on the policy-making process. PREREQUISITE: GV 1060.

GV 2161 INTRODUCTION TO INTERNATIONAL RELATIONS (4-0). The relations of nations, including a consideration of the factors of national power and study of international interests, and organizations.

GV 2163 WESTERN POLITICAL THOUGHT (4-0). Reading and analysis of the writings of the most important thinkers in the Western political tradition from Plato to Rousseau. Primary emphasis is placed upon how each writer dealt with the enduring and fundamental problems facing man in society such as justice, liberty, political obligation, social and political change, and the nature and purpose of society, government and the state. *(Graduate students register for GV 3163.)*

GV 2164 COMPARATIVE IDEOLOGIES (4-0). Analysis of the major ideological forces in contemporary world affairs and their effect upon foreign and defense policies. Special emphasis on Marxian political and social thought. Analysis and comparison on the concepts of democracy, socialism, and fascism. Use of primary source material. PREREQUISITE: A course (upper division or graduate) in the History of Western Philosophy or Political Theory. *(Graduate students register for GV 3164.)*

GV 2165 20th CENTURY SOCIAL AND POLITICAL THOUGHT (4-0). Analysis of leading ideas in American and European social and political thought of the 20th Century. Social and political aspects of pragmatism and existentialism: impact of sociology, psychology and anthropology on social and political thought; the interrelation of religious and political ideas and variant forms of recent political radicalism. *(Graduate students register for GV 3165.)*

GV 2166 MAJOR RELIGIONS, NATIONAL CULTURES, AND INTERNATIONAL AFFAIRS (4-0). A study of the major religions of the world (to include, but not be limited to, Christianity, Judaism, Islamism, Buddhism, Hinduism, Taoism, and Shintoism) and the effect that these religions have had on the national aspirations and the cultures of their adherents and on international problems. *(Graduate students register for GV 3166.)*

GV 2262 THEORY AND PRACTICE OF INTERNATIONAL POLITICS (4-0). A theoretical systematic analysis of international relations and a study of the factors, organizational strategies, and techniques of international politics. PREREQUISITE: GV 2161 or equivalent. *(Graduate students register for GV 3262.)*

GV 2268 PROBLEMS OF GOVERNMENT AND SECURITY IN CONTEMPORARY EUROPE (4-0). Problems of the European political system since World War II. Emphasis on the interrelation of the European states (EEC, EFTA, COMECON), the polarization of Europe between two security systems (NATO and the Warsaw Pact), and the relations between the European states and the Third World. *(Graduate students register for GV 3268.)*

GV 2272 AMERICAN TRADITIONS AND THE NATIONAL INTEREST (4-0). A study of the ideals and values which constitute the essential qualities of American life. The main purpose of this course is to define the American national interest in the international context and the effect of national security policy on the realization of national goals. PREREQUISITE: Course in American history or American government desirable. *(Graduate students register for GV 3272.)*

GV 2273 PROBLEMS OF AMERICAN SECURITY AND FOREIGN POLICY (4-0). Underlying assumptions and objectives of security and foreign policy; domestic pressures; policy formation and instruments of policy; security treaties and alliance systems; role of diplomacy in peaceful solutions; and the role of force. *(Graduate students register for GV 3273.)*

GV 2275 INTERNATIONAL LAW (4-0). An introduction to the principles of International Law including sovereignty, territory, recognition, the Law of the Sea, and the laws of war. A special emphasis on the Law of the Sea, its development, practice, and prospects. PREREQUISITE: GV 2161 desirable. *(Graduate students register for GV 3275.)*

GV 2279 DIRECTED STUDIES IN GOVERNMENT (Credit open). Independent study in government in subjects in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department. *(Graduate students register for GV 3279.)*

GV 2280 NUCLEAR WEAPONS AND FOREIGN POLICY (4-0). An interdisciplinary course which covers both the technology and

political influences of nuclear weapons systems. The course will emphasize the interaction of nuclear weapons systems with the foreign policies of the major powers and political blocs from 1945-present. *(Graduate students register for GV 3280.)* May also be offered as PH 2280.

GV 2300 PROBLEMS OF GOVERNMENT AND SECURITY IN THE MIDDLE EAST (4-0). An intensive study of social, cultural, and political aspects of the contemporary Middle East. Special attention is paid to the interaction of inter-Arab and international politics; the emergence and spread of nationalist ideologies and their consequences for major power strategies in the area. *(Graduate students register for GV 3300.)*

GV 2310 NORTH AFRICA: PROBLEMS OF GOVERNMENT AND SECURITY IN THE MAGHREB (4-0). Security and politics of the countries of North Africa and the Red Sea Littoral. The countries dealt with are Libya, Sudan, Ethiopia, Somalia, Algeria, Tunisia, and Morocco. This course is designed to extend the student's knowledge of these countries and to provide some insight into the security problems presented by their domestic politics. PREREQUISITE: Completion of the basic course in Middle Eastern politics would be preferred but is not required. *(Graduate students register for GV 3310.)*

GV 2320 INTERNATIONAL RELATIONS AND SECURITY PROBLEMS IN THE MIDDLE EAST (4-0). The course focuses on selected problems affecting American security interests in the Middle East: Strategic waterways, including the Suez Canal, the Turkish Straits, and the Indian Ocean; the politics and problems of access to the area's oil resources; the development of U. S. and Soviet policies toward the area. The foregoing problems will be set in the context of inter-Arab politics. PREREQUISITE: Completion of the first course in Middle Eastern Politics or consent of Instructor. *(Graduate students register for GV 3320.)*

GV 2400 PROBLEMS OF GOVERNMENT AND SECURITY IN THE SOVIET UNION (5-0). A study of cultural, social, economic, and political characteristics of the Soviet System and its role in international security affairs. Particular emphasis is given to recent changes in Soviet political development. *(Graduate students register for GV 3400.)*

GV 2410 SOVIET SECURITY AFFAIRS (4-0). An examination of the process by which Soviet security policy is made and executed, utilizing conflict models developed in the last few years. Particularly stressed will be the constraints on policy-making in the Soviet Union, the process by which defense priorities are established, and the manifestation of those priorities in specific instances of conflict in the contemporary world. PREREQUISITE: GV 2400 or permission of Instructor. *(Graduate students register for GV 3410.)*

GV 2500 PROBLEMS OF GOVERNMENT AND SECURITY IN THE CARIBBEAN AREA (4-0). A study of the political, economic, social, and cultural characteristics and the security problems of the countries in the Caribbean area. Included are Mexico, Central America, the Caribbean Island countries, the Guianas, Venezuela, and Colombia. *(Graduate students register for GV 3500.)*

GV 2510 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH AMERICA (4-0). A study of the political, economic, social, and cultural characteristics and the security problems of the countries in South America, excluding the Guianas. *(Graduate students register for GV 3510.)*

GV 2520 PROBLEMS OF DIPLOMACY AND SECURITY IN LATIN AMERICA (4-0). A study of the political, economic, and military relationships among the Latin American nations, and the role of Latin America in world politics. Special emphasis is placed on U. S. relations with Latin America. PREREQUISITE: GV 2500 or GV 2510 desirable. *(Graduate students register for GV 3520.)*

GV 2600 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTHEAST ASIA AND ADJACENT SEAS (4-0). Problems of modernization and revolution in the governments and economies of the states of Southeast Asia; cultural determinants; problems of ethnic minorities; role of religions; nationalism; communism and wars of liberation; the overseas Chinese problem; strategic interests of the major powers. *(Graduate students register for GV 3600.)*

GV 2610 PROBLEMS OF GOVERNMENT AND SECURITY IN EAST ASIA AND THE PACIFIC OCEAN (5-0). Problems of modernization, revolution, and conflict in the East Asian states. China's relations with contiguous states; Sino-Soviet state, party, and ideological differences; Chinese politics, and military and naval security affairs; Japan's new dynamic position; the U. S.-Japanese security problem; problems of the two Koreas; Soviet and American Far Eastern interests and policies; analysis of present and future naval capabilities and strategies of East Asian states. *(Graduate students register for GV 3610.)*

GV 2620 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH ASIA AND THE INDIAN OCEAN (4-0). Problems of nationalism, modernization, and security in the governments and economies of India, Pakistan, Afghanistan, and Ceylon. Indian-Pakistani relations; relations with China; the Tibetan and Kashmir problems; strategic interests of the major powers; Soviet interests and naval expansion in the Indian Ocean. *(Graduate students register for GV 3620.)*

GV 2800 PROBLEMS OF GOVERNMENT AND SECURITY OF THE SCANDINAVIAN-BALTIC REGION (4-0). This course will analyze the political, economic, social, and security problems faced by the Scandinavian-Baltic countries. The role they play on the northern flank of NATO will be examined as well as their position vis-a-vis the growing threat of Soviet military and naval power. *(Graduate students register for GV 3800.)*

Upper Division or Graduate Courses

Graduate Courses are designed to develop a capacity for problem analysis or to encourage opportunities for research specialization. All students should consult with the instructor before enrolling in any graduate course.

GV 3061 AMERICAN NATIONAL SECURITY POLICY (4-0). *(See GV 2061).*

GV 3062 INTELLIGENCE DATA ANALYSIS (4-2). A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of intelligence data. Topics include sampling methods, content analysis, data handling and processing overview, scaling techniques, and parametric and nonparametric tests with emphasis on application. The student will be exposed to a wide spectrum of data relating to international problems, with particular emphasis on international commerce and trade, and national maritime capabilities. PREREQUISITES: PS 3000 or equivalent, CS 2100. May also be offered as OS 3062.

GV 3163 WESTERN POLITICAL THOUGHT (4-0). *(See GV 2163.)*

GV 3164 COMPARATIVE IDEOLOGIES (4-0). *(See GV 2164.)*

GV 3165 TWENTIETH CENTURY SOCIAL AND POLITICAL THOUGHT (4-0). *(See GV 2165.)*

GV 3172 PUBLIC POLICY PROCESSES (4-0). A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May also be offered as MN 3172.

GV 3262 THEORY AND PRACTICE OF INTERNATIONAL POLITICS (4-0). *See* GV 2262.)

GV 3268 PROBLEMS OF GOVERNMENT AND SECURITY IN CONTEMPORARY EUROPE *(See* GV 2268.)

GV 3272 AMERICAN TRADITIONS AND THE NATIONAL INTEREST (4-0). *(See* GV 2272.)

GV 3273 PROBLEMS OF AMERICAN SECURITY AND FOREIGN POLICY (4-0.) *(See* GV 2273.)

GV 3275 INTERNATIONAL LAW (4-0). *(See* GV 2275.)

GV 3279 DIRECTED STUDIES IN GOVERNMENT. *(Credit open.)*

GV 3280 NUCLEAR WEAPONS AND FOREIGN POLICY (4-0). (*See* GV 2280.) May also be offered as PH 3280.

GV 3290 ADVANCED SPECIAL TOPICS (4-0). A graduate level colloquium seminar for students in the Departmental Honors Program. Content of the seminar will vary reflecting areas of potential specialization for students in the program. PREREQUISITE: Three courses at the 2000-level in an area of specialization; permission of Department Chairman.

GV 3300 PROBLEMS OF GOVERNMENT AND SECURITY IN THE MIDDLE EAST (4-0). (*See* GV 2300.)

GV 3310 NORTH AFRICA: PROBLEMS OF GOVERNMENT AND SECURITY IN THE MAGHREB (4-0). *(See* GV 2310.)

GV 3320 INTERNATIONAL RELATIONS AND SECURITY PROBLEMS IN THE MIDDLE EAST (4-0). (*See* GV 2320.)

GV 3400 PROBLEMS OF GOVERNMENT AND SECURITY IN THE SOVIET UNION. (5-0). (*See* GV 2400.)

GV 3410 SOVIET SECURITY AFFAIRS (4-0). (*See* GV 2410.)

GV 3420 SOVIET NAVAL AND MARITIME STRATEGY (4-0). This course seeks to provide students with a basic understanding of the roles played by the Soviet Navy, Merchant Marine, Fishing, and Oceanological Establishments in securing the objectives of the Soviet Government. Soviet naval and maritime strategy will be viewed within the context of the following factors: geography of the Soviet Union and surrounding waters, Soviet national objectives and nationalstrategy, Soviet political and international legal strategy, Soviet military strategy, Soviet economics and resources.

GV 3500 PROBLEMS OF GOVERNMENT AND SECURITY IN THE CARIBBEAN AREA (4-0). (*See* GV 2500.)

GV 3510 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH AMERICA (4-0). *(See* GV 2510)

GV 3520 PROBLEMS OF DIPLOMACY AND SECURITY IN LATIN AMERICA (4-0). *(See* GV 2520.)

GV 3600 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTHEAST ASIA AND ADJACENT SEAS (4-0). (*See* GV 2600.)

GV 3610 PROBLEMS OF GOVERNMENT AND SECURITY IN EAST ASIA AND THE PACIFIC OCEAN (5-0) *(See* GV 2610.)

GV 3620 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH ASIA AND THE INDIAN OCEAN (4-0) (*See* GV 2620).

GV 3800 PROBLEMS OF GOVERNMENT AND SECURITY OF THE SCANDINAVIAN-BALTIC REGIONS (4-0) *(See* GV 2800.)

GV 3900 INTERNATIONAL ORGANIZATION (4-0). Analysis of the international system, its evolution from separatism and alliances to multinational organization and beyond. American goals, objectives, and resources are examined in bilateral relationships, regional groupings, functional approaches, and general organization. Collective security and peacekeeping efforts, pacific settlement, arms control and disarmament, and institution building. PREREQUISITES: Completion of three quarters in the Operations Research/Systems Analysis Curriculum, B average or better, and the consent of Instructor.

GV 3901 OCEAN POLICY (4-0). Examination of policy choices for the United States and other governments concerning political, military, legal, environmental, and economic problems of the sea. Relates enviromental sciences to international policy and security problems by the systems approach. PREREQUISITES: Graduate standing, B average or better, and consent of the Instuctor.

GV 3902 SCIENCE, TECHNOLOGY, AND PUBLIC POLICY (4-0). An inquiry into the role of science and technology in the formulation and conduct of national policy. Interactions between scientific communities, government, and military services. Course is an elective for majors in departments of science or engineering: PREREQUISITES: Graduate standing, B average or better, with a major in the fields of science or engineering and the consent of Instructor. May also be offered as PH 3902.

GV 3903 SCIENCE, VALUES, AND CULTURE (4-0). The place of science in the modern world is one of the major problems of contemporary life. This course explores the problem through an analysis of culture as a whole. Each of the three major phases of the course deals with an aspect of this relationship. The first traces the background and development of modern science as a phase of Western culture. The second attempts to formulate a viable contemporary approach to the character of scientific inquiry. The third deals with the major philosophical, religious and moral issues involved in the relation of science and culture in our time. PREREQUISITE: Graduate standing and consent of Instructor. May also be offered as PH 3903.

Graduate Courses

GV 4063 FORECASTING, THREAT ANALYSIS AND NET ASSESSMENT (4-0). A study of the intuitive, exploratory and normative forecasting methods, including brainstorming, Delphi, time series, scenario writing, uncertainty, cost benefit, input-output approaches. Conflict modelling; introduction of models of armament races and international conflict. Implications of such models for analyzing threats; search procedures for generating alternatives. Net assessment of such alternatives. PREREQUISITES: OS 3207, GV/OS 3062. GV 3420. May also be offered as OS 4063.

GV 4207 SPECIAL TOPICS IN THE ANALYSIS OF INTELLIGENCE PROBLEMS (4-0). An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. Applications of cost/benefit and input-output modelling to intelligence decision problems such as collection management, collection system design, data handling and manipulation. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: GV/OS 3062, OS 3207, GV/OS 4063. May also be offered as OS 4207.

GV 4273 SPECIAL TOPICS IN AMERICAN SECURITY AND FOREIGN POLICY (4-0). An advanced study of the underlying assumptions and objectives of American security and foreign policy. Policy formulation; alliance and treaty systems; effects on security problems of budgets, weapons systems, research and development, international economic issues; the functioning of regional security systems in crises; problems of threat and intelligence determination. Use of primary source material. This course

is designed to develop a capacity for problem analysis or to encourage opportunities for research specialization. PREREQUISITES: GV 3400, GV 3610.

HISTORY

Upper Division Courses

HI 2100 EUROPEAN HISTORY (1815-1914) (4-0). Foreign and domestic affairs of the major European states from the Congress of Vienna to the outbreak of the First World War.

HI 2101 EUROPEAN HISTORY (1914-1945) (4-0). Foreign and domestic affairs of the major European states from the First World War through the immediate aftermath of the Second World War.

HI 2201 U. S. HISTORY (1763-1865) (4-0). A survey of the political, economic, and social history of the United States from the Colonial Period to the end of the Civil War.

HI 2202 U. S. HISTORY (1865-1945) (4-0). A survey of the political, economic, and social history of the United States from Reconstruction to the end of World War II.

HI 2203 CONTINUITY AND CHANGE IN RECENT AMERICA (4-0). Analysis of major developments in American life since 1945. Emphasis on change in the political and corporate structure; impact of national security affairs on American values; new artistic and intellectual currents; problems of race, technology, and education. *(Graduate students register for HI 3203.)*

HI 2239 DIRECTED STUDIES IN HISTORY (Credit open). Independent study in history in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department. *(Graduate students register for HI 3239.)*

Upper Division or Graduate Courses

Graduate courses are designed to develop a capacity for problem analysis or to encourage opportunities for research specialization. All students should consult with the instructor before enrolling in any graduate course.

HI 3032 HISTORY OF RECENT INSURGENCY WARFARE (4-0). Study of the more important insurgencies in recent history from the Russian Revolution of 1917 to the more recent uprisings on five major continents. The study covers the selected insurgencies in detail emphasizing the general historical forces operating, e.g., Nationalism, Socialism, Imperialism, etc., as well as the particular forms of development. Emphasis will be on accurate description of events in order to derive patterns of insurgency warfare.

HI 3203 CONTINUITY AND CHANGE IN RECENT AMERICA (4-0). *(See HI 2203.)*

HI 3239 DIRECTED STUDIES IN HISTORY (Credit open). *(See HI 2239.)*

LITERATURE

Upper Division Courses

LT 2239 DIRECTED STUDIES IN LITERATURE (credit open). Independent study in literature in subjects in which formal course work is not offered. PREREQUISITE: Permission of Department Chairman.

LT 2241 MASTERPIECES OF AMERICAN LITERATURE (4-0). A study of Puritanism, the Enlightenment, Romanticism, and Naturalism as these intellectual trends are found in the works of representative American writers.

LT 2243 MASTERPIECES OF EUROPEAN LITERATURE (4-0). A study of selected masterpieces of European literature. An effort is made to impress the student with the continuity of the Western European intellectual heritage. PREREQUISITE: Permission of Chairman of the Department.

PSYCHOLOGY

Upper Division Courses

PY 2050 GENERAL PSYCHOLOGY (4-0). A study of principles of rational and emotional processes in human thought and action.

PY 2251 APPLIED SOCIAL PSYCHOLOGY (4-0). An application of psychological principles to problems of personality growth, motivation, and interpersonal relations. PREREQUISITE: PY 2050 or permission of Chairman of Department.

SPEECH

Lower Division Course

SP 1020 PUBLIC SPEAKING (4-0). Practice in preparing and delivering extemporaneous speeches, emphasizing principles and techniques of oral style.

Upper Division Courses

SP 2020 COMMUNICATION MODELS FOR STAFF BRIEFING (0-2 to 4-0). Theoretic communication models applied to staff briefing. Practice in message analysis and design, presentation techniques/materials, interpersonal communication and persuasion with VTR feedback. The student must demonstrate research competence and creative application of theory. PREREQUISITE: SP 1020 or permission of Instructor.

SP 2021 STAFF SKILLS AND PROCEDURES (4-0). Staff study formats, investigation and data development, group procedures, oral presentation of completed staff study reports, group theory converted to classroom models. Emphasis upon completed staff work as an executive function. PREREQUISITE: SP 1020, staff experience, or permission of Instructor.

SP 2221 ADVANCED SPEECH (2-1). Practical application of techniques learned in SP 1020 with stress on composition, platform technique, audience situations, and audience response. Opportunity to address off-campus audiences is provided. PREREQUISITE: SP 1020 or equivalent. Enrollment limited.

SP 2300 PUBLIC AFFAIRS AND INTERNAL RELATIONS: MEDIA AND METHODS (3-2). Analysis of large organization, internal communication needs employing communication theory. Study of mass media principles and problems. Laboratory in public affairs situation control utilizing original research, group and individual problem-solving, simulations, role and game playing. PREREQUISITE: Permission of department chairman and curricular officer.

Upper Division or Graduate Course

SP 3020 COMMUNICATION MODELS FOR STAFF BRIEFING (0-2 to 4-0). *(See SP 2020.)*

INTERDISCIPLINARY GROUP PROJECTS

OBJECTIVE—The group project has the objective of presenting the student with a complex problem which has to be solved by systems-oriented methods. It offers an alternative to the conventional research project which presents the student with a well-defined problem to be solved by science-oriented methods.

The group project represents a complex system which cannot be solved by an individual effort. Its solution requires team work of specialists from the early phases of problem definition and conceptual design until an optimum solution is presented in the final report. It involves application of fundamental principles and analytical methods to the solution of complex problems. It includes many aspects of a problem, including social, economic and political factors.

Such a group project provides the student with an opportunity to participate in a creative effort, to broaden his understanding of real-life problems, and to become aware of the need for communicating with other disciplines.

DESCRIPTION—Participation in an Interdisciplinary Group project will be used in lieu of the thesis requirement for the Master of Science degree. Approval, on an individual basis, must be obtained in advance from the chairman of the student's major department. Enrollment in the project should occur in two consecutive quarters during the last three quarters of the student's program. The courses will be offered only if sufficient enrollment, a minimum of twelve, is obtained with representation from at least three disciplines.

It shall be the responsibility of the students to define the problem, develop a project management plan, solve the problem, and write the final report. The management plan shall account for:

a. group organization.
b. determination of problem solution goals and assignment of these goals to project members.
c. schedule of completion dates for the goals.
d. development of a format for weekly progress reports.

GROUP PROJECTS

GP 0910 ADVANCED PROJECT (4-0). This is the first of a two-course sequence in which students and faculty from three or more disciplines work together as a team to solve as completely as is feasible a specific problem. The purpose of the course is to offer students the opportunity to formulate and solve a complex problem of current interest using systems-oriented methods. The scope and details of the problem are defined by the faculty and students. PREREQUISITE: Permission of Department Chairman.

GP 0911 ADVANCE PROJECT (8-0). Continuation of GP 0910.

Captain Roger S. Case, Jr., U.S. Air Force, receiving his Doctor of Philosophy hood from Provost Jack R. Borsting

DEPARTMENT OF MATHEMATICS

WALTER MAX WOODS, Professor of Mathematics and Statistics; Chairman (1961)*; B.S. Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

DAVID ANDERSON ARCHER, Lieutenant (junior grade), U. S. Naval Reserve; Assistant Professor of Mathematics (1972); B.A., Texas Christian Univ., 1969; M.A., Rice Univ., 1972; Ph.D., 1973.

ROBERT COWDALL BAMFORD, Ensign, U. S. Naval Reserve; Instructor in Mathematics (1972); B.S., Hobart College, 1966; M.A., Harvard Univ., 1967.

GERALD LEONARD BARKSDALE, JR., Assistant Professor of Computer Science and Mathematics (1967); B.S., Rice Univ., 1965; M.S., 1966.

WILLARD EVAN BLEICK, Professor of Mathematics (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

RAYMOND HARVEY BRUBAKER, JR., Lieutenant (junior grade), U. S. Naval Reserve; Assistant Professor of Mathematics (1971); B.S., Univ. of California at Los Angeles, 1971; M.S., 1971.

CRAIG COMSTOCK, Professor of Mathematics (1970); B.E.P., Cornell Univ., 1956; M.S., Naval Postgraduate School, 1961; Ph.D., Harvard Univ., 1965.

LAWRENCE LEO DANFORTH, Lieutenant Commander, U. S. Navy; Instructor in Mathematics (1973); B.S., Univ. of California at Berkeley, 1963; M.S., Naval Postgraduate School, 1972.

DANIEL LEE DAVIS, Assistant Professor of Mathematics (1969); B.S., Georgia Institute of Technology, 1965; Ph.D, California Institute of Technology, 1969.

FRANK DAVID FAULKNER, Distinguished Professor of Mathematics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942; Ph.D., Univ. of Michigan, 1969.

JOHN DUDLEY FINNERTY, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Mathematics (1973); A.B., Williams College, 1971; B.A., Univ. of Cambridge, 1973.

RICHARD HOMER FRANKE, Assistant Professor of Mathematics (1970); B.S., Fort Hays Kansas State College, 1959; B.S., Univ. of Utah, 1961; Ph.D., 1970.

ROBERT EUGENE GASKELL, Professor of Mathematics (1966); A.B., Albion College, 1933; M.S., Univ. of Michigan 1934; Ph.D., 1940.

GREGORY DEAN GIBBONS, Assistant Professor of Mathematics (1970); B.A., Univ. of California at Santa Barbara, 1963, Ph.D., Carnegie-Mellon Univ., 1972.

BENNET ALAN GOLD, Lieutenant Commander, U.S. Navy; Instructor in Mathematics (1973); B.A., Stanford Univ., 1960; M.S., Naval Postgraduate School, 1970.

ROBERT MARTIN HANNA, Commander, U. S. Navy; Assistant Professor of Mathematics (1971); B.S., Univ. of Kansas, 1958; M.S., Naval Postgraduate School, 1966.

RICHARD CARL HANSEN, Lieutenant Commander, U. S. Navy; Instructor in Computer Science and Mathematics (1974); B.S. Univ. of California at Los Angeles, 1961; M.S., Naval Postgraduate School, 1970.

TOKE JAYACHANDRAN, Associate Professor of Mathematics (1967); B.S., V. R. College, Nellore, India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

WALTER JENNINGS, Professor of Mathematics (1947); B.A., Ohio State Univ., 1932, B.S., 1932; M.A., 1934.

DAVID HARBET KENT, Ensign, U. S. Naval Reserve; Instructor in Mathematics (1973); B.S., Southwest Texas State Univ., 1970; M.A., 1971.

GARY ARLEN KILDALL, Assistant Professor of Mathematics (1969); B.S., Univ. of Washington, 1967; M.S., 1968; Ph.D., 1972.

UNO ROBERT KODRES, Associate Professor of Mathematics (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

LADIS DANIEL KOVACH, Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.A., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

THOMAS JEFFREY LOGAN, Lieutenant, U. S. Naval Reserve; Instructor in Mathematics (1972); B.S., Univ. of North Carolina, 1970; M.S., Univ. of Michigan, 1971.

KENNETH ROBERT LUCAS, Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Kansas Univ., 1957.

HERMAN BERNARD MARKS, Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

LOUIS ROBERT MOORE, III, Lieutenant, U. S. Naval Reserve; Instructor in Mathematics (1972); B.S., Villanova Univ., 1970.

GEORGE WILLIAM MORRIS, Professor of Mathematics (1968); B.A., Southwestern Institute of Technology, 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., Univ. of California at Los Angeles, 1957.

JOHN PHILIP PIERCE, Professor of Mathematics (1948); B.S. E.E., Worcester Polytechnic Institute of Brooklyn, 1931; M.S.E.E., Polytechnic Institute of Brooklyn, 1937.

GARY MICHAEL RAETZ, Ensign, U. S. Navy; Instructor in Computer Science and Mathematics (1973); B.S., Portland State Univ., 1972; M.S. Naval Postgraduate School, 1973.

DAVID WALTER ROBINSON, Lieutenant, U. S. Navy; Instructor in Mathematics (1973); B.S., U. S. Naval Academy, 1965; M.S., Naval Postgraduate School, 1973.

IRA BERT RUSSAK, Associate Professor of Mathematics (1972); M.E., Stevens Institute of Technology, 1957; M.A., Univ. of California at Los Angeles, 1962; Ph.D., 1967.

ARUTHR LORING SCHOENSTADT, Assistant Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

ALAN MCKEAN SHORB, Associate Professor of Mathematics (1968); B.A., Swarthmore College, 1960; M.A., Cornell Univ., 1965; Ph.D., Univ. of Minnesota, 1969.

ELMO JOSEPH STEWART, Professor of Mathematics (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Univ., 1953.

GLENN ALLEN STOOPS, Assistant Professor of Mathematics (1970); S.B., Massachusetts Institute of Technology, 1961; S.M., 1962; Ph.D., Rice Univ., 1967.

DONALD HERBERT TRAHAN, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

PETER CHENG-CHAO WANG, Associate Professor of Mathematics (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

MAURICE DEAN WEIR, Associate Professor of Mathematics (1969); B.A., Whitman College, 1961; M.S., Carnegie-Mellon Univ., 1963; D.A., 1970.

CARROLL ORVILLE WILDE, Associate Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

JAMES WOODROW WILSON, Professor of Mathematics (1949); B.A., Stephen F. Austin State, 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S. in Ch.E., Texas A&M College, 1941.

EMERITUS FACULTY

HORACE CROOKHAM AYRES, Professor Emeritus (1958); B.S., Univ. of Washington, 1931; M.S., 1931; Ph.D., Univ. of California at Berkeley, 1936.

JOSEPH GIARRATANA, Professor Emeritus (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

CARL ADOLF HERING, Professor Emeritus (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

FRANCIS MCCONNELL PULLIAM, Professor Emeritus (1949); B.A., Univ. of Illinois, 1937; M.A., 1938; Ph.D., 1947.

CHARLES HENRY RAWLINS, JR., Professor Emeritus (1922); Ph.B., Dickinson College, 1910; M.A., 1913; Ph.D., Johns Hopkins Univ., 1916.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers a Bachelor of Science or a Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. The program, and subsequent changes in the program, must be approved by the Departmental Chairman.

BACHELOR OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. Of the total quarter hours specified in the general requirements for the degree of Bachelor of Science, a student majoring in mathematics must complete at least 30 quarter hours of approved course work in mathematics beyond calculus, and must have an average QPR of 2.25 or greater in these 30 quarter hours.

2. The following topics are specifically included in any major program. Courses listed in parentheses or their equivalents may be used to satisfy the requirements.

a. 6 hours of Analysis (MA 3605-3606)
b. 6 hours of Algebra (MA 3046-3047)
c. 4 hours of Differential Equations (MA 2121)
d. 3 hours of Complex Analysis (MA 2172)
e. 4 hours of Probability and Statistics (PS 2501)

MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to the Master of Science degree with major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics, as stated above. A student whose background does not satisfy this requirement may take course work to eliminate this deficiency. However, such courses cannot be counted toward satisfying the Departmental requirements for the degree of Master of Science.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 3.0 or greater in any major program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics.

4. The following topics are specifically included in any major program:

a. 6 hours of Algebra
b. 6 hours of Analysis

5. The main areas for thesis topics are

a. Computer Science
b. Differential Equations
c. Fourier Analysis

d. Functional Analysis
e. Numerical Methods
f. Optimal Control
g. Probability and Statistics
h. Tensor Analysis and Applications

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in mathematics at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Mathematics Department. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MATHEMATICS

MA 0110 REFRESHER MATHEMATICS (5-5). General category for those students who cannot be properly evaluated due to lack of transcript or questionable academic record.

MA 0111 REFRESHER MATHEMATICS (5-5). Operations Analysis refresher for students preparing to take MA 2109.

MA 0112 REFRESHER MATHEMATICS (5-5). Calculus review for students who need to validate MA 1100.

MA 0113 REFRESHER MATHEMATICS (5-5). Algebra review for students whose first course is MA 1021 or MA 2300.

MA 0114 REFRESHER MATHEMATICS (5-5). Pre-calculus review for students whose first course is MA 1120.

MA 0115 REFRESHER MATHEMATICS (5-5). General calculus review for students whose first course is MA 1100.

MA 0118 MATHEMATICS REFRESHER (3-3). Review of trigonometry, vector algebra, and complex numbers for Operational Systems Technology (ASW) students.

MA 0119 MATHEMATICS REFRESHER (3-3). Review of differential and integral calculus for Operational Systems Technology (ASW) students preparing to take MA 2129.

MA 0125 LOGIC AND SET THEORY (5-0). An introduction to the elements of set theory and mathematical reasoning. Sets, Venn diagrams, truth tables, quantifiers, logical reasoning. Functions, relations, partitions and equivalence relations, 1-1 correspondence. (Paradoxes of set theory, axiom of choice.) PREREQUISITE: None.

MA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MA 1010 INTERMEDIATE ALGEBRA (4-0). The set of real numbers and postulates for the development of the algebra of real numbers. Proofs of some elementary theorems for the algebra of the real numbers. Applications of the postulates and theorems to addition, subtraction, multiplication, division and factoring of algebraic expressions. Application to word problems, first degree equations and equations of higher degree. Functions, graphs and inequalities. Exponents and logarithms. Sequences, series and the binomial theorem. Complex numbers. PREREQUISITE: None.

MA 1021 PRECALCULUS MATHEMATICS (4-0). Brief review of algebraic fundamentals. Algebra of complex numbers, quadratic equations. Systems of equations, determinants, Cramer's rule. Binomial theorem. Mathematical induction. Trigonometric functions of the general angle. Identities. Solution of right and oblique triangles. Elements of the theory of equations. Introduction to analytic geometry. PREREQUISITE: MA 1010 or equivalent.

MA 1100 CALCULUS REVIEW (4-0). Functions of one variable, limits, derivatives, continuity, indefinite and definite integrals, transcendental functions. Taylor's theorem; vectors in two and three dimensions, functions of several variables, partial derivatives, multiple integration. PREREQUISITE: A previous course in calculus.

MA 1115 CALCULUS I (5-0). Introduction to plane analytic geometry, functions of one variable, limits, continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, elementary vector algebra, vector differentiations. PREREQUISITE: Some previous work in calculus.

MA 1116 CALCULUS II (5-0). Polar coordinates, vector algebra and vector calculus in three dimensional space, functions of several variables, double and triple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1115.

MA 1120 CALCULUS AND ANALYTIC GEOMETRY I (5-2). Introduction to plane analytic geometry, functions of one variable, limits, continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, elementary vector algebra, vector differentiations. PREREQUISITE: MA 1021.

MA 1121 CALCULUS AND ANALYTIC GEOMETRY II (5-2). Polar coordinates, vector algebra and vector calculus in three dimensional space, functions of several variables, double and triple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1115 or MA 1120.

MA 1130 CALCULUS I (4-0). Introduction to plane analytic geometry; functions of one variable, limits, continuity, derivatives, indefinite and definite integrals. PREREQUISITE: MA 1021 or equivalent.

MA 1131 CALCULUS II (4-0). Transcendental functions, conic sections, elementary vector algebra, functions of several variables, partial differentiation. PREREQUISITE: MA 1130 or equivalent.

MA 1132 CALCULUS III (4-0). Vector calculus, multiple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1131 or equivalent.

Upper Division Courses

MA 2025 LOGIC, SETS AND FINITE MATHEMATICS (4-0). Propositional logic and elements of set theory. Relations, functions and partitions. Elements of finite probability theory. PREREQUISITE: None.

MA 2040 MATRIX ALGEBRA (2-0). Linear equations, systems of linear equations, determinants, matrices and vectors, addition and multiplication of matrices, inverse of a matrix, partitioned matrices, vector spaces and subspaces, rank of a matrix. This course is designed primarily for students in management. PREREQUISITE: College algebra.

MA 2042 LINEAR ALGEBRA (4-0). Systems of linear equations, matrices, and determinants. Finite dimensional vector spaces, linear dependence, basis, dimension, inner products, orthogonali-

zation. Linear transformations, rank and nullity, change of basis, linear functionals, orthogonal transformations, quadratic forms, symmetric matrices, diagonalization, eigenvalues and eigenvectors. PREREQUISITE: MA 2109 or MA 1116.

MA 2045 INTRODUCTION TO LINEAR ALGEBRA (3-0). Complex numbers. Systems of linear algebraic equations. Matrix algebra. Vector spaces. Rank. Inverse by Gauss' method. Determinants. Adjoint and inverse. Characteristic equations, roots and vectors—proper axes for quadratic surface, solution of system of differential equations. Orthogonal reduction to diagonal form. PREREQUISITE: MA 1100 or equivalent.

MA 2047 LINEAR ALGEBRA AND VECTOR ANALYSIS (4-0). Systems of linear equations. Matrix algebra. Inverse by Gauss' method. Determinants. Adjoint and inverse. Vector spaces. Rank. Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems. PREREQUISITE: MA 1100 or equivalent.

MA 2048 LINEAR ALGEBRA AND VECTOR ANALYSIS (5-0). Algebra of matrices. Determinants. Elementary matrices, rank of matrix and inverse of a matrix. Linear vector spaces, subspaces, linear dependence and independence, basis and dimension. Systems of homogeneous and non-homogeneous linear equations and their solutions. Eigenvalues and vectors. Similar matrices and quadratic forms. Algebra of vectors in R^2 and R^3. Calculus of these vectors. Del operator, directional derivative, gradient, divergence and curl with applications. Vector integration, line integrals, surface and volume integrals. Green's, Stokes' and the Divergence Theorem. PREREQUISITE: MA 1100 or equivalent.

MA 2109 TOPICS IN CALCULUS (5-0). A selection of miscellaneous topics such as differential equations, vector analysis in three space, three-dimensional differential and integral calculus, infinite series. PREREQUISITE: Differential and integral calculus.

MA 2110 MULTIVARIABLE CALCULUS (4-0). Integrated with linear algebra. Functions of several variables, continuous transformation, jacobians, chain rule, implicit function theorem, inverse function theorem, extrema, LaGrange multiplier technique, curvilinear coordinates. PREREQUISITES: MA 2109 and MA 2042 (the latter may be taken concurrently).

MA 2121 DIFFERENTIAL EQUATIONS (4-0). Ordinary differential equations: homogeneous and nonhomogeneous equations, linear independence of solutions, linear and non-linear equations, power series solutions, systems of differential equations, applications. PREREQUISITE: MA 1100 or equivalent, MA 2045 or equivalent concurrently.

MA 2129 ELEMENTS OF LINEAR ALGEBRA, ORDINARY DIFFERENTIAL EQUATIONS, AND FOURIER SERIES (4-0). Systems of linear equations, solution by the echelon method, matrix and determinant solutions. First order ordinary differential equations, second order equations with constant coefficients, applications. Fourier series and orthogonality, representation of elementary functions, and solution of ordinary differential equations. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: Differential and integral calculus.

MA 2161 INTRODUCTION TO MATHEMATICAL PHYSICS (5-0). An introduction to the techniques used in solving problems in classical field theories. Vector and scalar fields are studied. Potential fields for fluid flow using curvilinear coordinates. Analytic functions of a complex variable. Residue theory with application to Fourier and Laplace transforms. Conformal mapping. PREREQUISITE: MA 1110 and MA 2121 (the latter may be taken concurrently).

MA 2172 COMPLEX VARIABLES (4-0). Analytic functions, integration and series representations. Residue theory and application to Laplace transform. Conformal mapping and applications. PREREQUISITE: MA 2121 or equivalent.

MA 2181 VECTOR CALCULUS (2-0). Differentiation and integration of vector functions. The del operator and related concepts. Green's theorem, Stokes' theorem, divergence theorem. Interpretations and applications. This course is intended for students in the Operational Systems Technology (ASW) curriculum. PREREQUISITES: Calculus and vector algebra.

MA 2232 NUMERICAL METHODS (3-1). Error propagation. Evaluation of functions. Nonlinear equations. Linear algebra for computers. Interpolation. Least squares approximation. Numerical integration. Ordinary differential equations. PREREQUISITE: MA 2121 and CS 0110 or equivalent.

MA 2300 MATHEMATICS FOR MANAGEMENT (5-0). This course is designed to provide mathematical basis for modern managerial tools and techniques. It includes elements of differential and integral calculus, sequences and series and an introduction to matrix algebra. PREREQUISITE: College algebra.

MA 2305 DIFFERENTIAL CALCULUS (3-0). Brief review of algebra, differential calculus of power functions, logarithmic functions and exponential functions; multivariable calculus; maxima and minima with and without constraints. Applications will be primarily from field of economics and management. This is the first of a two-course sequence in calculus designed primarily for students in management. PREREQUISITE: College algebra.

MA 2306 INTEGRAL CALCULUS (2-0). Integral calculus of power functions, logarithmic functions and exponential functions. This course is designed primarily for students in management. PREREQUISITE: MA 2305 or equivalent.

Upper Division or Graduate Courses

MA 3026 TOPICS IN DISCRETE MATHEMATICS (4-0). Review of mathematical induction. Elements of number theory: divisibility, congruences and prime numbers. Generating functions and combinatorial problems. Elements of graph theory. PREREQUISITE: MA 2025.

MA 3046 LINEAR ALGEBRA (3-0). Special types of matrices. Orthogonal reduction of a real symmetric matrix to diagonal form. Quadratic forms and reductions to expressions involving only squares of the variables. Applications to maxima and minima. Lambda matrices and related topics. Cayley-Hamilton theorem. PREREQUISITE: MA 2045.

MA 3047 LINEAR ALGEBRA (3-0). Reduced characteristic function. Canonical forms. Idempotent and nilpotent matrices. Solutions to matrix polynomial equations. Functions of a square matrix. Applications such as to differential equations, stability criteria. PREREQUISITE: MA 3046.

MA 3130 DIFFERENTIAL EQUATIONS (4-0). Review of linear ordinary differential equations. Separation of variables for partial differential equations. Fourier Series and orthogonal functions. Series solutions and special functions. Boundary value problems in two and three dimensions. PREREQUISITES: MA 1100, MA 2047 and ordinary differential equations.

MA 3132 PARTIAL DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (4-0). Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3139 PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS FOR WAVE PROPAGATION (4-0). Solutions of the one, two, and three-dimensional wave equations by separation of variables and characteristics; ray propagation; brief discussion of Laplace's and heat equation; Fourier and Laplace transforma-

tions applied to ordinary and partial differential equations; convolution theorems. This course is designed for the Operational Systems Technology (ASW) program. PREREQUISITE: MA 2129.

MA 3173 COMPLEX VARIABLES AND LAPLACE TRANSFORMS (4-0). Continuation of MA 3130. Complex variables, contour integration, residue theory, conformal mapping; applications to ordinary and partial differential equations including Laplace transforms and their complex inversion. PREREQUISITE: MA 3130.

MA 3181 VECTOR ANALYSIS (3-0). Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1100 or equivalent.

MA 3185 TENSOR ANALYSIS (3-0). Definition of a tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The co-variant derivative and its application to geodesics. The Riemann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3232 NUMERICAL ANALYSIS (3-2). Solution of equations. Zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations. Numerical solutions of ordinary differential equations. PREREQUISITE: MA 2121 and FORTRAN programming or equivalent.

MA 3243 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS (4-1). Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. The implicit alternating direction method. Approximations at irregular boundaries. Elliptic equations. The Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. A term project involving the solution of a suitably difficult boundary value problem is required. PREREQUISITE: MA 3132 or equivalent.

MA 3362 ORBITAL MECHANICS (3-0). Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. Perturbations. PREREQUISITE: A course in dynamics.

MA 3560 MODERN APPLIED ALGEBRA (3-0). An introductory course in the techniques and tools of abstract algebra with special emphasis on applications to coding theory, radar and communications systems, and computer science. Elements of set theory, equivalence relations and partitions. Semigroups, groups, subgroups and homomorphisms. Rings, ideals and fields. Directed graphs and lattices. Applications may vary. PREREQUISITE: Consent of Instructor.

MA 3565 MODERN ALGEBRA I (3-0). An advanced course in the subject of abstract algebra. Semigroups, groups, subgroups, normal subgroups. Groups acting on sets, operator groups. The Jordan-Holder Theorem, solvable groups. The Krull Schmidt Theorem. PREREQUISITE: MA 3560 or consent of Instructor.

MA 3605 FUNDAMENTALS OF ANALYSIS I (3-0). Elements of set theory, the real number system, and the usual topology in E^N Properties of continuous functions. Differentials of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorems, extremum problems). PREREQUISITE: Consent of Instructor.

MA 3606 FUNDAMENTALS OF ANALYSIS II (3-0). Functions of bounded variation and theory of Riemann-Stieltjes integration. Multiple and iterated integrals. Convergence theorems for sequences and series of functions. PREREQUISITE: MA 3605.

MA 3610 INTRODUCTION TO GENERAL TOPOLOGY (3-0). Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures. Tychonoff product theorem, Alexandroff and Stone-Cech compactification. PREREQUISITE: MA 3605.

MA 3660 BOUNDARY VALUE PROBLEMS (3-0). The partial differential equations of physics and their solutions by separation of variables. Orthogonal sets of functions; Fourier series, their convergence and other properties. Applications to boundary value problems, verification and uniqueness of solutions. Continuation to include Bessel functions and Legendre polynomials. PREREQUISITE: MA 2121 or equivalent.

MA 3675 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I (3-0). Selected topics from the theory of functions of a real variable. Complex functions and analytic functions. Integration in the complex plane. Series of complex functions. Power series. Laurent series. PREREQUISITE: Consent of Instructor.

MA 3676 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE II (3-0). Singularities of complex functions. Residues and contour integration. Zeros of analytic functions, factors of and infinite product representations for analytic functions. Maximum modulus theorems for analytic and harmonic functions. Conformal mapping. PREREQUISITE: MA 3675.

MA 3730 THEORY OF NUMERICAL COMPUTATION (3-0). Analysis of computational methods used for the solution of problems from the areas of algebraic equations,polynomial approximation, numerical differentiation and integration, and numerical solution of ordinary differential equations. PREREQUISITE: Consent of Instructor.

Graduate Courses

MA 4237 ADVANCED TOPICS IN NUMERICAL ANALYSIS (4-0). The subject matter will vary according to the abilities and interests of those enrolled. PREREQUISITE: MA 3243. Graded on Pass/Fail basis only.

MA 4375 MATHEMATICS OF CONTINUA (4-0). Stress and strain analysis. Constitutive relations. Field equations of elastodynamics, thermodynamics, and hydrodynamics. Wave propagation and diffusion in layered media. Reflection and transmission at boundaries between dissimilar materials. Media with continuously varying characteristics. PREREQUISITE: MA 3173 or consent of Instructor.

MA 4393 TOPICS IN APPLIED MATHEMATICS (3-0). A selection of topics in applied mathematics. The course content varies. Credit may be granted for taking this course more than once. PREREQUISITE: Consent of Instructor.

MA 4501 TOPICS IN FOUNDATIONS OF MATHEMATICS (3-0). A selection of topics in foundations of mathematics. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

MA 4566 MODERN ALGEBRA II (3-0). A continuation of MA 3565. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynomial rings. Modules and ideals. Noetherian rings. Field extension and Galois theory. PREREQUISITE: MA 3565.

MA 4593 TOPICS IN ALGEBRA (3-0). A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

MA 4610 TOPOLOGY OF DYNAMICAL SYSTEMS (3-0). Dynamical systems, trajectories, limiting sets, recursive concepts, dispersive concepts, stability theory. PREREQUISITES: MA 2121 and either MA 3605 or MA 3610.

MA 4611 CALCULUS OF VARIATIONS (3-0). Bliss differential methods, Euler equations, Weierstrass-maximum principle, Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and applications to engineering and control problems. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4620 THEORY OF ORDINARY DIFFERENTIAL EQUATIONS (3-0). Introduction to the modern theory of ordinary differential equations. Systems of equations. Theoretical and constructive methods of solutions. PREREQUISITE: Consent of Instructor.

MA 4622 PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS I (3-0). Linear operators, generalized functions and Hilbert spaces. Solutions of partial differential equations by eigenfunctions. Variational techniques and their applications to eigenfunctions. Classification of partial differential equations. PREREQUISITE: MA 3132 or equivalent and MA 2172 or equivalent.

MA 4623 PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS II (3-0). Continuation of MA 4622. Green's functions. Integral equations, Laplace, Fourier and other transforms, including their inversion in the complex plane as applied to partial differential equations. Method of characteristics for hyperbolic equations. PREREQUISITE: MA 4622.

MA 4635 FUNCTIONS OF REAL VARIABLES I (3-0). Axiomatic set theory, development of the real numbers, semi-continuous functions, absolutely continuous functions, functions of bounded variation. Classical Lebesgue measure and integration theory, convergence theorems and Lp spaces. PREREQUISITE: MA 3606.

MA 4636 FUNCTIONS OF REAL VARIABLES II (3-0). Abstract measure and integration theory, signed measures, Radon-Nikodym theorem. Lebesgue decomposition and product measures. Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 4635.

MA 4637 INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). An introduction to Banach and Hilbert spaces, including open mapping-closed graph theorem, weak and weak star topologies, spectral theorems for compact Hermitian operators. Hermitian bounded and normal bounded operators. PREREQUISITE: MA 4636.

MA 4672 INTEGRAL TRANSFORMS (3-0). The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2172.

MA 4693 TOPICS IN ANALYSIS (3-0). A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4872 TOPICS IN CALCULUS OF VARIATIONS (3-0). Recent developments in the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applied to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: spectral variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121, MA 3045 and computer programming or Consent of Instructor.

PROBABILITY AND STATISTICS

Upper Division Courses

PS 2000 ELEMENTARY PROBABILITY AND STATISTICS (4-0). A pre-calculus treatment of selected topics in probability and statistics. Includes elementary probability, binomial distribution, normal distribution, random sampling, testing hypotheses, confidence limits, regression and correlation. PREREQUISITE: College algebra.

PS 2315 DATA REDUCTION AND ERROR ANALYSIS (4-0). An introduction to the practical techniques and procedures of experiment design, data acquisition and reduction, and error analysis in the physical sciences and engineering. Topics will include systematic and random errors, distributions, estimates of distribution parameters, least-squares fitting, multiple regression, tests of goodness-of-fit, and computer techniques for the treatment of data. PREREQUISITES: CS 0110 or equivalent, MA 1100 and MA 2045.

PS 2501 INTRODUCTION TO PROBABILITY AND STATISTICS (4-0). Selected topics from basic probability and statistics, using some elementary calculus concepts. Topics include probability axioms, discrete and continuous random variables, typical distributions, independence and independent sampling, and point and interval estimation. PREREQUISITES: MA 1115, MA 1120 or equivalent.

Upper Division or Graduate Courses

PS 3000 PROBABILITY AND STATISTICS FOR NAVAL INTELLIGENCE AND COMMUNICATIONS MANAGEMENT (4-0 or 5-0). An introductory course in probability and statistics designed for applications to Naval Intelligence and Communications Management problems. The topics covered will include frequency distributions and descriptive measures, rules for computing probabilities, binomial and normal distributions, central limit theorem, sampling distributions, statistical inference including regression, and analysis of variance. PREREQUISITE: College algebra.

PS 3005 PROBABILITY (3-0). A one-quarter course in probability. Random variables, probability mass functions, density functions, sample spaces, probability axioms, independence, moments, derived distributions, Bayes Theorem, sampling, sample statistics. This course is designed primarily for students in management. PREREQUISITE: MA 2305 or equivalent.

PS 3011 PROBABILITY AND STATISTICS FOR MANAGEMENT I (5-0). A treatment of selected topics in probability and statistics for management applications using elementary concepts from calculus. Includes probability models, discrete and continuous random variables, some important distributions, sampling theory and an introduction to statistical inference. PREREQUISITE: MA 2300 or equivalent.

PS 3012 PROBABILITY AND STATISTICS FOR MANAGEMENT II (4-0). A continuation of PS 3011. Includes inference for normal populations, estimation procedures, nonparametric procedures and linear models. PREREQUISITE: PS 3011 or consent of Instructor.

PS 3401 INTERMEDIATE PROBABILITY AND STATISTICS I (4-0). A course in probability using the tools of calculus and leading toward applications in mathematical statistics. Includes topics from set theory, definition and calculation of probability, random variables and distribution functions, some standard distributions, joint distributions. PREREQUISITE: MA 1100 or equivalent.

PS 3402 INTERMEDIATE PROBABILITY AND STATISTICS II (4-0). A continuation of PS 3401 covering topics from mathematical statistics. Includes topics from sampling and statistics, estimation and testing hypotheses, Bayesian methods, and least squares regression theory. PREREQUISITE: PS 3401 or consent of Instructor.

PS 3411 APPLIED PROBABILITY THEORY I (4-1). Axiomatic probability, random variables, distribution functions, transformation of random variables, limiting distribution, stationary and ergodic processes. PREREQUISITE: MA 2121.

PS 3412 APPLIED PROBABILITY THEORY II (4-0). Stochastic processes, time series, linear mean-square estimation. Brownian motion and Markov processes and Poisson processes. PREREQUISITE: PS 3411 or consent of Instructor.

PS 3414 APPLIED PROBABILITY AND STATISTICS (4-0). A first course in applied probability and statistics for students with a background in mathematics and engineering. Discrete and continuous distributions, sampling, estimation, hypotheses testing, regression analysis, applications to reliability and system effectiveness modeling and measurement. PREREQUISITE: Courses in differential and integral calculus.

PS 3415 ENGINEERING STATISTICS (4-1). A course in statistics leading towards applications in engineering problems. The topics include sampling theory, point and interval estimation, hypothesis testing, regression analysis and analysis of variance; applications in quality control, sampling inspection and reliability problems will be emphasized. PREREQUISITE: PS 3411 or equivalent.

PS 3421 NONPARAMETRIC STATISTICS (4-0). One-sample tests, two-sample tests, tests for independence, nonparametric analysis of variance and correlation statistics. PREREQUISITE: Consent of Instructor.

Graduate Courses

PS 4001 PROBABILITY THEORY (3-0). Axiomatic probability, random variables and their probability distributions, parameters of probability distributions, characteristic functions and limit theorems. PREREQUISITE: Advanced calculus or consent of Instructor.

PS 4002 STATISTICS AND DECISION THEORY (3-0). Sample moments and their functions, order statistics, theory of runs, significance tests and theory of estimation. PREREQUISITE: PS 4001 or consent of Instructor.

PS 4325 DESIGN OF EXPERIMENTS (4-0). Incomplete block designs. Youden squares, fractional designs, response surfaces and robustness properties of analysis of variance tests. PREREQUISITE: OA 4321.

PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: Consent of Instructor.

Halligan Hall

DEPARTMENT OF MECHANICAL ENGINEERING

ROBERT HARRY NUNN, Associate Professor of Mechanical Engineering; Chairman (1968)*, B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

JOHN EDISON BROCK, Professor of Mechanical Engineering (1954); B.S.M.E., Purdue Univ., 1938; M.S.E., 1941; Ph.D., Univ. of Minnesota, 1950.

JOSEPH GILLES CANTIN, Professor of Mechanical Engineering (1960); B.A.Sc., Ecole Polytechnique at Montreal, 1950; M.Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

THOMAS EDWARD COOPER, Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Berkeley, 1966; M.S.M.E., 1967; Ph.D., 1970.

GLEN ROBERT EDWARDS, Assistant Professor of Materials Science (1971); B.S. in Met. Eng., Colorado School of Mines, 1961; M.S., Univ. of New Mexico, 1967; Ph.D., Stanford Univ., 1971.

CLARENCE JIMMY GARRISON, Associate Professor of Mechanical Engineering (1970); B.S.M.E., Univ. of Nebraska, 1960; M.S.M.E., 1962; Ph.D., Univ. of Washington, 1968.

THOMAS MICHAEL HOULIHAN, Associate Professor of Mechanical Engineering (1969); B.M.E., Manhattan College, 1961; Ph.D., Syracuse Univ., 1968.

MATTHEW DENNIS KELLEHER, Associate Professor of Mechanical Engineering (1967); B.S. Univ. of Notre Dame, 1961; M.S.M.E., 1963, Ph.D., 1966.

PAUL JAMES MARTO, Associate Professor of Mechanical Engineering (1965); B.S., Univ. of Notre Dame, 1960; M.S. in Nuc.Sci., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

EDWIN ALBERT MCKINNON, Assistant Professor of Mechanical Engineering (1972); B.Met.E., Univ. of Nevada, 1965; M.S.M.E., 1967; Ph.D., Univ. of Wisconsin, 1972.

ROBERT EUGENE NEWTON, Professor of Mechanical Engineering (1951); B.S.M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

DONG HUU NGUYEN, Associate Professor of Mechanical Engineering (1969); B.S.M.E., Purdue Univ., 1960; M.S. in Nuc.Eng., 1961; Ph.D., Univ. of California at Berkeley, 1965.

ARTHUR JEFFERY PERKINS, Assistant Professor of Mechanical Engineering (1972); B.S., Drexel Institute of Technology, 1965; M.S., Case Institute of Technology, 1967; Ph.D. in Metallurgy, Case Western Reserve University, 1969.

ROY WALTERS PROWELL, Professor of Mechanical Engineering (1946); B.S. in I.E., Lehigh Univ., 1936; M.S.M.E., Univ. of Pittsburgh, 1943.

PAUL FRANCIS PUCCI, Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

DAVID SALINAS, Assistant Professor of Mechanical Engineering (1970); B.S., Univ. of California at Los Angeles, 1959; M.S. 1962; Ph.D., 1968.

TURGUT SARPKAYA, Professor of Mechanical Engineering (1967); M.S.M.E., Tech. Univ. of Istanbul, 1951; Ph.D., Univ. of Iowa, 1954.

EMERITUS FACULTY

ERNEST KENNETH GATCOMBE, Professor Emeritus (1946); B.S., Univ. of Maine, 1931; M.S., Purdue Univ., 1939; Ph.D., Cornell Univ., 1944.

HAROLD MARSHALL WRIGHT Professor Emeritus (1945); B.Sc. in M.E., North Carolina State College, 1930; M.M.E., Rensselaer Polytechnic Institute, 1931.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

1. *Entrance Requirements.* Prior to entering an approved curriculum, a student must have successfully completed college courses as follows: mathematics through integral calculus, one year of chemistry, and one year of physics.

2. *Mechanical Engineering Courses.* A minimum of 54 quarter hours in mechanical engineering courses is required, at least 26 of them being at or above the 3000 level.

3. *Other Specific Coverage.* The following minimum requirements must be met in each of the indicated disciplines:

Mathematics through partial differential equations—14 quarter hours.
Electrical Engineering—8 quarter hours.
Materials Science—4 quarter hours.

4. *Upper Division Credit.* Minimum credit of 80 quarter hours in upper division or higher level courses is required.

5. *Sample Program.* A sample program satisfying the above requirements is given under Naval Engineering Programs, Curriculum No. 570.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

1. *Areas of Specialization.* Within the program leading to the degree of Master of Science in Mechanical Engineering, faculty and facilities are available to provide emphasis upon the following areas of study: engineering mechanics, fluid mechanics, heat transfer, materials science, nuclear engineering, and ocean mechanical engineering.

2. *Undergraduate Preparation.* A candidate shall have satisfied the requirements for the degree of Bachelor of Science in Engineering. Credit requirement in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

3. *Mechanical Engineering Courses.* The Master of Science degree in Mechanical Engineering requires a minimum of 36 quarter hours of graduate level credits, at least 10 of them in courses 4000-4999, plus an acceptable thesis.

4. *Courses in Other Departments.* A minimum of 8 quarter hours of graduate credit must be earned outside of the Mechanical Engineering Department.

5. *Sample Program.* Various sample programs leading to the Master of Science degree in Mechanical Engineering are given under Naval Engineering Programs Curriculum No. 570.

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in mechanical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Mechanical Engineering Department. A total of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

THE PROGRAM LEADING TO THE DEGREE OF MECHANICAL ENGINEER

Graduate students may, upon satisfactory completion of seven quarters of academic work, enter the program leading to the degree of Mechanical Engineer. Normally, this program does not exceed a total duration of three years.

The Engineer's degree requires a minimum of 76 graduate course credits, at least 30 of them in courses 4000-4999, plus an acceptable thesis related to the area of specialization previously noted. An acceptable thesis for the Engineer's degree may also be accepted as meeting the thesis requirements for the Master's degree.

An advisor will be appointed by the Departmental Chairman for consultation in the development of a program of study and research. Approval of all programs must be obtained from the Chairman, Department of Mechanical Engineering.

THE PROGRAM LEADING TO THE DEGREE OF DOCTOR OF PHILOSOPHY

Graduate officer students may, upon satisfactory completion of eleven quarters of academic work, apply for the program leading to the degree of Doctor of Philosophy. Normally, this program requires the equivalent of at least one academic year being spent at the Naval Postgraduate School. A Doctoral Committee is appointed for the student which has the full responsibility for providing a program of study suitable to the needs of the student and the requirements for award of the degree.

The Department of Mechanical Engineering is authorized to offer doctorate degrees in the areas of mechanics of deformable bodies, fluid mechanics, and heat transfer.

A dissertation advisor is appointed by the Department Chairman who, together with the Doctoral Committee, is responsible for the development of a program of study and research. Approval of the programs must be obtained from the Academic Council.

In order to provide civilian scientists and engineers of the Navy an opportunity to extend their education to the doctoral level, admission to the Ph.D. program is available to qualified applicants for the Cooperative Doctoral Program. Interested individuals should address their inquiries to the Provost of the Naval Postgraduate School.

MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to the extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes machinery for the investigation of dynamic and static problems in engineering mechanics; a completely equipped materials science laboratory; a scanning electron microscope; a water tunnel, a water table, and a wave channel; facilities for experimentation with air flows from incompressible through supersonic velocities; equipment for instruction in thermal transport phenomena; a laboratory for demonstrating nuclear engineering principles; and a fluid power control and fluidics laboratory. The experimentation adventure is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

MECHANICAL ENGINEERING

ME 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

ME 2101 ENGINEERING THERMODYNAMICS (4-1). A comprehensive coverage of the fundamental concepts of classical thermodynamics, with insight toward microscopic phenomena. The laws of thermodynamics. Equations of state. Thermodynamic

properties of substances. Entropy, irreversibility and availability. Cycle analysis. Gas-vapor mixtures. Combustion and dissociation. PREREQUISITE: MA 1100.

ME 2120 ELEMENTS OF ENGINEERING THERMODYNAMICS (3-2). The fundamental concepts of thermodynamics, thermodynamic properties and equations of state. The first law of thermodynamics. Entropy and the second law of thermodynamics. The ideal gas. Gaseous mixtures. Cycle analysis with some applications. PREREQUISITE: PH 1015.

ME 2201 INTRODUCTION TO FLUID MECHANICS (3-2). Properties of fluids. Fluid statics, stability of submerged bodies. Mass, momentum, and energy considerations in steady flows. Dynamic similitude and dimensional analysis. Fluid measurement and control, turbo-machinery. Basic effects of fluid friction. Emphasis on naval engineering applications and problem solving. PREREQUISITE: ME 2502.

ME 2410 MECHANICAL ENGINEERING LAB I (2-3). Fundamentals of mechanical measurement systems, structured laboratory experiments using resistance strain gages, pressure transducers, temperature flow and velocity measurement devices. PREREQUISITES: ME 2101, ME 2201, ME 2502, and ME 2610, any of which may be taken concurrently. Graded on Pass/Fail basis only.

ME 2502 DYNAMICS (4-0). Kinematics and kinetics of a particle. Work and energy. Impulse and momentum. Plane motion of a rigid body. PREREQUISITE: ME 2610 or ME 2561 or equivalent.

ME 2561 STATICS (3-0). This course, designed specifically for the B.S. in Engineering Science Curriculum, deals with forces and force systems, moments and couples, resultants, equilibrants, free body diagrams, equilibrium, simple structures, friction, first and second moments, and centroids. PREREQUISITE: MA 1106.

ME 2562 DYNAMICS (4-0). This course, designed specifically for the B.S. in Engineering Science Curriculum, deals with basic concepts of kinematics, Newton's laws, d'Alembert's principle, work and energy, impulse and momentum, plane motion of a rigid body. PREREQUISITE: ME 2561.

ME 2610 MECHANICS OF SOLIDS I (5-2). This course combines the fundamentals of statics and a first course in mechanics of solids. Topics include laws of equilibrium in vector form, applications to structures and machines, centroids and second moments, shear and bending moment diagrams, uniaxial and biaxial stresses and deformations, torsion of circular members, shear and bending stresses in beams, beam deflections, simple statically indeterminate problems. Supporting laboratory experiments in mechanics of solids. PREREQUISITE: MA 1100 (may be taken concurrently).

Upper Division or Graduate Courses

ME 3150 HEAT TRANSFER (4-2). Elementary treatment of the principles of Heat Transfer applicable to problems in Mechanical Engineering. Steady and unsteady conduction. Principles of forced and natural convection. Thermal radiation. Boiling. Condensation. Heat exchanger analysis. Use of the thermal circuit, analog, numerical and graphical techniques. Selected laboratory experiments. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3201 PRINCIPLES OF FLUID DYNAMICS (3-1). An introduction to the methods of analysis of ideal and viscous fluid flows. Concepts of steady fluid motion and dynamics in three dimensions. Motion of a deformable body. Simple irrotational flows. Vortex dynamics. Momentum and moment of momentum. Compressibility effects and one-dimensional compressible flows. Gravity flows. Fundamentals of viscous fluid flows. PREREQUISITES: MA 3132 (may be taken concurrently), ME 2201.

ME 3202 GAS DYNAMICS (3-1). The effects of compressibility and the basic equations governing compressible flows. Wave propagation in compressible media. One-dimensional adiabatic flows. Rayleigh flows. Prandtl-Meyer flow. Normal and oblique shock waves. Current Mechanical Engineering applications, devices, and systems. PREREQUISITES: ME 2101 and ME 2201.

ME 3301 NUCLEAR POWER SYSTEMS (5-0). Atomic and nuclear structures. Nuclear reactions: fission and fusion. Neutron interactions with matter: cross section, slowing-down and diffusion of neutrons. Fundamentals of nuclear reactor analysis: neutronic and thermal aspects in core design. Principal reactor types. Biological radiation protection. Applications of radioisotopes. PREREQUISITES: ME 3150 (may be taken concurrently) or equivalent.

ME 3315 NUCLEAR MEASUREMENTS LAB (1-4). Principles of radiation detection. The use of various health physics instruments and radiation detectors; gas-filled, scintillation, crystal and foil detectors; calibration of detectors. Experiments in neutron physics: determination of neutron Fermi age and diffusion length. Neutron fast and thermal fluxes mapping by various detectors. Determination of flux perturbation by local absorption. Gamma ray spectrometry: pulse height analyzer. PREREQUISITES: ME 2410, ME 3301 or equivalent.

ME 3341 RADIATION SHIELDING (4-0). Biological hazards of nuclear radiations. Interaction of electromagnetic radiation, charged particles, and neutrons with matter. Shielding of reactors and radioactive materials. Miscellaneous topics in shielding: effects of ducts and voids in shields, heating with shields, beam traps, shielding windows. PREREQUISITES: ME 3301 or equivalent.

ME 3430 MECHANICAL ENGINEERING LAB II (1-3). A project-oriented continuation of mechanical measurement systems, with emphasis upon the use of sound engineering practices in the conduct and documentation of an independent experimental investigation. Application of measurement techniques using group projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations and nuclear radiation detection. PREREQUISITES: ME 2410, ME 3150, ME 3521, and ME 3611. Graded on Pass/Fail basis only.

ME 3440 ENGINEERING SYSTEMS ANALYSIS (4-0). Classification of engineering problems. Study of equilibrium, eigenvalue and propagation problems for both discrete and continuous systems. Rigorous construction of mathematical models. Classical methods of solution and numerical techniques. Digital computer applications. Problems in the theory of plates and shells, heat transfer, hydromechanics, and other areas of Mechanical Engineering are used as illustrations throughout the course. PREREQUISITES: ME 2101, ME 2201, ME 3521, and ME 3611.

ME 3450 THERMODYNAMICS OF MARINE POWER SYSTEMS (3-2). Current applications of thermodynamic principles to Marine Power Systems. Detailed analysis of vapor and gas power cycles. The characteristics of engines, compressors, and turbines. Refrigeration, air conditioning and cryogenic systems. Direct energy conversion. Selected laboratory experiments. PREREQUISITE: ME 3150.

ME 3500 MECHANICAL VIBRATIONS AND NOISE CONTROL (4-0). Free and forced vibrations of discrete and continuous linear systems. Damping mechanisms, including complex modulus description of materials. Mechanical impedance. Transfer matrices. Case studies of shipboard vibration and noise problems. PREREQUISITES: MA 2232 or equivalent, PH 3157, and PH 3451.

ME 3521 MECHANICAL VIBRATIONS (3-2). Kinematics and kinetics of free and forced vibration of discrete linear systems. Applications to vibration isolation and suppression in mechanical

systems. Vibration of bars, shafts and beams. Numerical solutions. Laboratory experiments with mechanical and simulated systems. PREREQUISITES: ME 2502, ME 2610, MA 2232, and MA 3132 (may be taken concurrently).

ME 3611 MECHANICS OF SOLIDS II (4-0). Constitutive laws for linear elastic solids. Fundamentals of the theory of elasticity. Applications to beams. Stability of simple structures. Torsion of members with non-circular cross section. Elements of plate and shell behavior. PREREQUISITES: ME 2502, ME 2601, MA 2121, and MA 2232.

ME 3711 DESIGN OF MACHINE ELEMENTS (3-2). The design of screw fastenings, springs, shafts, bearings, gears, flexible power-transmitting elements, brakes and clutches are studied with consideration being given to materials, tolerances, variable loads, stress concentration and theories of failure. PREREQUISITE: ME 3611.

ME 3712 DESIGN OF MACHINERY (2-4). Static, kinematic and dynamic analysis and design of cams, gears and linkages. Projects involving conceptual design of complete machines. Consideration is given to manufacturing and machining methods. PREREQUISITES: ME 3711 and ME 3521.

ME 3801 FLUID POWER CONTROL (3-2). Fluids as power transmission media. Operation and analysis of control valves and actuators. Hydraulic power elements. Steady state and dynamic performance of electro-hydraulic servovalves and servomechanisms. Design criteria for fluid power controls. Introduction of pneumatic systems. Some time-dependent flow problems. Introduction to fluidics. PREREQUISITE: ME 3201 (may be taken concurrently).

Graduate Courses

ME 4140 DIRECT ENERGY CONVERSION (3-0). The principles of direct energy conversion employing thermoelectric, thermionic, photo voltaic, magneto-hydrodynamic, and fuel cell power generators. PREREQUISITES: ME 3150, ME 3202, EE 2101, and MA 2121.

ME 4161 CONDUCTION AND RADIATION HEAT TRANSFER (4-0). Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Variational methods. Mechanical Engineering applications. Black body radiation; radiation from real surfaces; radiation exchange between finite surfaces. The network method, radiation through participating media. Conjugate conduction and radiation problems. PREREQUISITE: ME 3150.

ME 4162 CONVECTION HEAT TRANSFER (4-0). Fundamental principles of forced and free convection. Dimensionless correlations. Heat transfer during phase changes. Combined conduction, convection and radiation heat transfer systems. Heat exchanger analysis with Mechanical Engineering applications. PREREQUISITES: ME 4161, ME 4220 (may be taken concurrently).

ME 4211 HYDRODYNAMICS (4-0). Kinematics and dynamics of inviscid fluid flow. Vorticity, circulation, velocity potential and stream function. Solutions to flow about two- and three-dimensional bodies. Simple unsteady flows—virtual mass. Conformal transformations, hydrofoils, approximate methods. Introduction to free streamline flows and fluid wave motions with naval engineering applications. PREREQUISITE: ME 3201.

ME 4220 VISCOUS FLOW (4-0). Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Low Reynolds number flows. Development of the boundary layer equations. Similarity variables, numerical and integral techniques. Separation, boundary layer control, compressibility effects. Time-dependent boundary layers. Stability, transition, and turbulence. Nature of turbulence, phenomenological theories, calculation of turbulent flows. PREREQUISITE: ME 4211 (may be taken concurrently).

ME 4230 ADVANCED TOPICS IN FLUID DYNAMICS AND HEAT TRANSFER (4-0). Topics selected in accordance with the research interests of students and staff. Advanced analytical methods. Surveys of current Mechanical Engineering technologies. Extensions to the theories of fluid flow and heat transfer. PREREQUISITES: ME 4161, ME 4211, ME 4220, and MA 2172 (may be taken concurrently), or consent of Instructor.

ME 4240 ADVANCED HYDRODYNAMICS (4-0). Topics selected in accordance with the current research interests of students and staff. Jets, wakes, cavities; free-streamline theory. Steady and unsteady separated flows. Analysis of rotating fluid masses. Wave propagation in complex systems. PREREQUISITES: ME 4211, MA 3173 (may be taken concurrently), or consent of Instructor.

ME 4311 NUCLEAR REACTOR ANALYSIS I (4-0). Review of neutron interactions with matter. Neutron cross sections; resonance phenomena and Doppler effect. The fission process. The slowing-down of neutrons in media with and without absorption. The diffusion of neutrons. Space-dependent slowing down of neutrons: Fermi Age Theory. Low-energy neutrons and thermal reactors. Criticality of homogeneous reactors. PREREQUISITES: ME 3301 or equivalent and MA 3132.

ME 4312 NUCLEAR REACTOR ANALYSIS II (4-0). Design parameters in heterogeneous reactors. Reflected reactors. Multigroup diffusion methods. Reactor kinetics and control: the effect of delayed neutrons; step and ram change in reactivity. Reactor properties over life: temperature coefficients of reactivity; fission product poisoning; burn-up and conversion. Application of perturbation theory in the analysis of reactivity change. PREREQUISITE: ME 4311.

ME 4321 REACTOR ENGINEERING PRINCIPLES AND DESIGN (4-2). Reactor heat generation and removal. Thermal stress analysis. Nuclear Fuel Cell. Change in reactivity during core lifetime. Overriding of fission product poisoning. Principal types of reactor systems. The synthesis of reactor physics, heat transfer and hydraulics, properties of materials and safety requirements in reactor design. Student group design project. PREREQUISITES: ME 4312, ME 3450 (may be taken concurrently).

ME 4512 ADVANCED DYNAMICS (4-0). Three-dimensional kinematics of particles and rigid bodies. The inertia tensor. Dyadic-vector formulation of dynamical equations. Lagrangian methods. Topics of special interest such as Hamiltonian methods, space dynamics, electromechanical systems. PREREQUISITE: ME 3521.

ME 4522 ADVANCED VIBRATIONS (4-0). Matrix analysis of mechanical systems with many degrees of freedom. Transient response. Shock isolation. Non-linear systems. Digital computer solutions. PREREQUISITE: ME 3521.

ME 4612 ADVANCED MECHANICS OF SOLIDS (4-0). Stress tensor and theories of inelastic action. Selected applications of the theory of elasticity. Topics of special interest, such as instability of simple framed structures, matrix methods of structural analysis, analysis of pressure vessels, thermal stresses. PREREQUISITES: MA 3132 and ME 3611.

ME 4613 FINITE ELEMENT METHODS (4-0). Systematic construction of line, surface, and volume elements for one-, two- and three-dimensional problems of elasticity. Applications to trusses, frames, plane stress and plane strain problems, plates and shells, with emphasis on ship structures. Extensions to vibrations, buckling, and large deformations. PREREQUISITE: ME 3611.

ME 4620 THEORY OF CONTINUOUS MEDIA (4-0). Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy

and entropy. Constitutive equations. Mechanical applications in the theory of elasticity and fluid dynamics. PREREQUISITES: ME 2201, ME 3611, and MA 3132.

ME 4902 ADVANCED STUDY IN MECHANICAL ENGINEERING (2-0 to 6-0). Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. Graded on Pass/Fail basis only.

MATERIALS

MS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Course

MS 1021 ELEMENTS OF MATERIALS SCIENCE I (3-2). An introduction to the structure and properties of materials for engineering application. Structure on the microstructural level is considered in terms of its relationship to chemical, physical, and mechanical behavior. Introduction to atomic bonding, crystal structure, crystalline defects, strengthening mechanisms, plastic deformation, and brittle fracture. PREREQUISITE: CH 1001 or equivalent.

Upper Division Courses

MS 2022 ELEMENTS OF MATERIALS SCIENCE II (3-2). Continuation of sequence of subject matter of MS 1021. Phase equilibria, heat treatment, diffusion, and phase transformations in technologically important alloy systems are among the topics covered. Discussion of environmental deterioration of materials and suggestions for interpreting and avoiding service failures. PREREQUISITE: MS 1021.

MS 2201 ENGINEERING MATERIALS (3-2). The fundamental principles of materials science are presented with particular emphasis on mechanical behavior. The effects of atomic structure, crystal structure, and microstructure on properties of structural materials are emphasized. Crystalline defects, deformation processes, strengthening mechanisms, brittle fracture, phase equilibria, heat treatment, and microstructural control are discussed with reference to practical examples. Laboratory exercises parallel and illustrate key lecture points. The course aims at providing the Naval Engineering student with the vocabulary and conceptual understanding necessary for further study or for communicating with materials experts. PREREQUISITE: Elementary courses in physics and chemistry.

MS 2218 ELEMENTS OF ENGINEERING MATERIALS (3-2). Course content and development parallels MS 2201 with emphasis on Aeronautical and Aerospace applications. Mechanical properties/structure relationships are emphasized in discussion of crystal structure, defects, deformation, fracture, phase equilibria, heat treatment, and environmental deterioration. PREREQUISITE: Elementary courses in physics and chemistry.

Upper Division or Graduate Courses

MS 3202 PROPERTIES, PROBLEMS, AND FAILURES OF STRUCTURAL MATERIALS (3-2). Topics of interest to the Naval and Aero engineer are emphasized through case studies of actual failures. The cause(s) of each failure is presented, and the necessary background material to fully understand the phenomena is then provided in each case. The common theme is that the service behavior of structure materials can be generally related to microstructure and defects therein. Failures due to fatigue, brittle fracture, radiation damage, stress corrosion, and fabrication deficiencies are among those discussed. Selection of materials and modern methods of materials analysis are treated. The course structure is flexible so that specific student interest can be accommodated. PREREQUISITE: MS 2201 or equivalent, or permission of Instructor.

MS 3206 IMPERFECTIONS IN CRYSTALLINE SOLIDS (3-0). The effects of crystalline defects on the physical and mechanical behavior of solids are discussed. This course examines in moderate detail those microstructural features which have a major impact on materials development, fabrication and utilization. Subjects chosen may include such topics as point defects in materials for electronics, dislocation interactions, strain-aging phenomena, the role of stacking faults in material failure, and sub-grain strengthening. PREREQUISITE: MS 2201 or equivalent.

MS 3304 CORROSION (3-2). Presents the basic chemical, electrochemical, mechanical, and metallurgical factors which influence the corrosion, oxidation, and deterioration of materials. Discusses standard methods of corrosion control, such as cathodic protection coatings, cladding, alloy selection, and inhibitors; special problems encountered in unfamiliar environments. PREREQUISITE: MS 2201 or equivalent.

MS 3312 ADVANCED MATERIALS (4-0). The course is structured to provide a vehicle for the study of materials pertinent to a specific area of environmental utilization or design. Example categories are nuclear materials, materials for use at elevated temperatures, materials for ocean engineering, and materials for aeronautical engineering. Topics discussed are modes of material failure, materials selection, materials testing, and new concepts in materials engineering. Course scope may he confined to one of the aforementioned categories or may include several categories, to he decided by mutual agreement of class and instructor. PREREQUISITE: MS 2201 or equivalent.

MS 3401 MICROSCOPY (3-2). Electron microscopy and sophisticated light optical microscopic techniques are emphasized in a coverage of useful, modern methods of microscopic observation. Techniques covered include scanning electron microscopy, transmission electron microscopy, conventional microprohe analysis, field ion microscopy, polarized light microscopy and stereo, interference, phase contrast, and holographic light optical methods. Course and lab will simultaneously cover both theory and practice, including specimen preparation, instrument design and operation, and applications. PREREQUISITE: Consent of Instructor.

Graduate Courses

MS 4215 PHASE TRANSFORMATION (3-2). Structural changes which commonly occur in materials by various mechanisms are considered. Solidification, precipitation, recrystallization, and martensitic transformations are emphasized, both in principle and in regard to their technological importance. Principles of nucleation and growth, diffusion and kinetics are presented and their relevance to practical heat treating and fabrication processes are considered. PREREQUISITE: MS 2201 or equivalent.

MS 4302 SPECIAL TOPICS IN MATERIALS SCIENCE (Hours by arrangement.) Independent study of advanced subjects not regularly offered. PREREQUISITE: Consent of Instructor.

MS 4305 MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS (3-0). The properties and preparation of materials used in electrical and electronic applications. Among the materials discussed are ferro-magnetic materials, both hard and soft, ferrimagnetic materials, semi-conductors, both elemental and compound, insulators and dielectrics, piezoelectric and ferroelectric crystals. The electronic, crystallographic and thermodynamic

principles controlling these materials are discussed and the heat treatments, compositions, and methods of fabrication of commercial materials are emphasized. PREREQUISITE: MS 2201 or equivalent.

MS 4811 MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS (3-2). The response of structural materials to mechanical stress is discussed with emphasis on plastic deformation in metals. Topics include mechanisms of high-temperature deformation, fatigue, and fracture. New concepts of alloy development which circumvent these failure mechanisms are treated. PREREQUISITES: MS 3202 or permission of Instructor.

Root Hall houses the Departments of Mechanical Engineering and Meteorology

DEPARTMENT OF METEOROLOGY

GEORGE JOSEPH HALTINER, Distinguished Professor and Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

DONALD EDWARD CAVERLY, LCDR, U. S. Navy; Instructor in Meteorology (1974). B.A., Rice Univ., 1959; M.S., Naval Postgraduate School, 1964.

CHIH-PEI CHANG, Assistant Professor of Meteorology (1972); B.S., National Taiwan Univ., 1966; Ph.D., Univ. of Washington, 1972.

KENNETH LA VERN DAVIDSON, Associate Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

RUSSELL LEONARD ELSBERRY, Associate Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

ROBERT LEE HANEY, Assistant Professor of Meteorology (1970); A.B., George Washington Univ. 1964; Ph.D., Univ. of California at Los Angeles, 1971.

JERRY DEAN JARRELL, Commander, U.S. Navy; Instructor in Meteorology (1973); B.S., Concord College, 1956; M.S., Naval Postgraduate School, 1967; M.S., 1973.

JOSEPH DAVID MACKENZIE, Commander, U.S. Navy; Assistant Professor of Meteorology (1972); B.S., Naval Academy, 1955; M.S. Naval Postgraduate School, 1960.

FRANK LLIONEL MARTIN, Professor of Meteorology (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

ROBERT JOSEPH RENARD, Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

CHARLES LUTHER TAYLOR, Associate Professor of Meteorology (1954); B.S., Pennsylvania State Univ., 1942; M.S., 1947.

MARTIN STEPHEN TRACTON, Assistant Professor of Meteorology (1972); B.S., Univ. of Massachusetts, 1966; M.S., Massachusetts Institute of Technology, 1969; Ph.D., 1972.

WILLEM VAN DER BIJL, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State University, Utrecht, 1952.

ROGER TERRY WILLIAMS, Professor of Meteorology, (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

EMERITUS FACULTY

WILLIAM DWIGHT DUTHIE, Distinguished Professor Emeritus (1945); B.A., Univ. of Washington, 1935; M.S. 1937; Ph.D., Princeton Univ., 1940.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN METEOROLOGY

BACHELOR OF SCIENCE IN METEOROLOGY

1. Thedegree of Bachelor of Science in Meteorology requires completion of:

   a. Mathematics courses including differential and integral calculus, vectors, digital computers, and numerical methods.
   b. Thirty-six quarter hours of meteorology courses including the basic sequences in dynamic, physical and synoptic meteorology.
   c. An acceptable research paper.

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

   a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.
   b. Thirty-five quarter hours of graduate meteorology courses of which 18 hours must be in the 4000 series.
   c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, must be included in these 35 hours.
   d. An acceptable thesis.

DOCTOR OF PHILOSOPHY

The Ph.D. is offered in the Department of Meteorology in the following areas of study; numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems, and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, examination in both the major and a minor field, and languages. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology also requires a preliminary examination in order to show evidence of acceptability as a doctoral candidate.

Prospective students should consult with the Chairman of the Department of Meteorology for further information and guidance regarding doctoral programs.

METEOROLOGY LABORATORIES

Meteorology facilities include all instruments in present-day use for measuring the physical and dynamic state of the atmosphere, as well as radio teletype and facsimile communications equipment

for the rapid reception and dissemination of weather data in coded and analyzed form for the entire northern hemisphere.

The instruments for gathering weather data include rawinsonde equipment, which provides a continuous recording of temperature, pressure, humidity and wind direction and velocities at designated levels above the surface; radiosonde equipment whereby pressure, temperature and humidity information is transmitted to ground via radio signals from heights that may extend above 30 km; a wiresonde that measures air temperature and humidity conditions in the lower strata of the atmosphere, and inversion meter designed for remote recordings of free air temperature at designated heights in the boundary layer.

The school has in daily operation an automatic picture transmission (APT) receiving apparatus for the reception of pictures from the NIMBUS, ESSA, and ATS weather satellites. Rectification grid templates are used in the laboratories for direct correlation of current satellite pictures with conventional synoptic analyses and nephanalyses.

The proximity of the Fleet Numerical Weather Central provides introduction to the latest environmental computer products and the high speed data links utilized to provide transmission and automatic reproduction through a world-wide network. In addition, the Navy research facility known as the Environmental Prediction Research Facility (EPRF) has been established in the local area and will aid the NPS programs in meteorological and oceanographic research.

METEOROLOGY

MR 0110 FACULTY SEMINAR (1-0). An introduction to the faculty. Purpose is to hear descriptions of research and teaching interests of the members of both faculties (Meteorology and Oceanography) as an orientation and as a first opportunity for exposure to possible thesis research areas. Presentations by individual faculty members. PREREQUISITE: Enrollment in Environmental Sciences Curricula. Graded on Pass/Fail basis only.

MR 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

MR 2100 SURVEY OF METEOROLOGY (3-0). A descriptive course which treats the composition and vertical structure of the atmosphere, physical processes, general circulation, air masses, fronts, cyclones, anti-cyclones, and tropical disturbances. PREREQUISITE: None.

MR 2200 INTRODUCTION TO METEOROLOGY (4-0). A general course which introduces basic instruments, the physical laws governing atmospheric processes, the composition and vertical structure of the atmosphere, physical processes, cyclones and anti-cyclones, air masses, fronts, tropical disturbances, general circulation and observations from satellites. PREREQUISITES: Differential and integral calculus, PH 1011 or equivalent, or departmental approval.

MR 2205 INTRODUCTION TO METEOROLOGICAL ANALYSIS (0-4). A laboratory course in meteorological and oceanographical observations and codes; and, an introduction to the vertical structure of the troposphere and basic analysis of meteorological parameters. 500mb analysis is used to emphasize the importance of time continuity, gradients and the geostrophic wind; surface analysis focuses on the additional problems associated with frontal phenomena; graphical arithmetic techniques are practiced. PREREQUISITE: MR 2200.

MR 2210 MARINE METEOROLOGY FOR OCEANOGRAPHERS (4-3). This introductory course treats the composition and structure of the atmosphere, thermodynamical processes, forces and related small-and large-scale motions, air masses, fronts, severe storms, solar and terrestrial radiation and weather forecasting. Emphasis is on the coupling between the ocean and atmosphere. Laboratory periods are devoted to exercises illustrating lecture material including weather map analysis. PREREQUISITE: Calculus; can be taken concurrently.

MR 2420 PRINCIPLES OF MEASUREMENT (3-2). The application of the basic principles of mechanics, heat, electricity, sound and optics to meteorological instrumentation employed by the Navy with special emphasis on upper air and satellite developments. PREREQUISITE: MA 2121.

MR 2430 ENVIRONMENTAL POLLUTION (3-0). A survey of air and water pollution theory and associated problems with specific case studies. Pertinent basic principles from oceanography and meteorology will be presented. May also be offered as OC 2430. PREREQUISITE: None.

MR 2520 CLIMATOLOGY AND STATISTICS (3-1). Discussion of climatic controls, climatic classifications and hypotheses about climatic changes. Preview of the climates of certain areas of the world which are important to the Navy. Many basic statistical quantities (mean, standard deviation, correlation and regression) will be introduced and their role in climatology demonstrated. PREREQUISITE: MR 2200.

Upper Division or Graduate Courses

MR 3220 METEOROLOGICAL ANALYSIS (3-0). Techniques of evaluation, analysis and interpretation of tropospheric pressure, wind and temperature data, including an introduction to interpretation of weather satellite observations. Synoptic models of extra-tropical vortices, waves and frontal systems, with emphasis on three-dimensional space and time continuity of the lower troposphere. Introduction to space and time cross-sections and streamline and isotach analysis. PREREQUISITES: MR 2200 and MR 3420; MR 4321 concurrently.

MR 3225 METEOROLOGICAL ANALYSIS LABORATORY (0-6). Laboratory course with emphasis on analysis of vertical consistency between the surface and 500mb levels; introduction to analysis at 850 and 300mb; use of weather satellite observations in analysis; practice in local weather briefing. PREREQUISITE: MR 3220 concurrently.

MR 3230 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY (4-0). Observation, computation, analysis, and synoptic interpretation of tropospheric and stratospheric data (to 10mb) with emphasis on the middle and high altitude aspects of satellite meteorology, jet streams, tropopauses, vertical motion, hydrometeors, and related numerical products. PREREQUISITES: MR 3220; MR 4322 concurrently.

MR 3235 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY LABORATORY (0-9). Practice in the meso-and synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships, and application to forecast problems. PREREQUISITE: MR 3225; MR 3230 concurrently.

MR 3250 TROPICAL METEOROLOGY (3-0). The general circulation, climatology and synoptic models of the tropics; analysis and forecasting tropical weather systems with emphasis on cyclones and meteorological satellite observations. PREREQUISITES: MR 4322, MR 3230.

MR 3255 TROPICAL METEOROLOGY LABORATORY (0-6). Laboratory course associated with MR 3250. Contour (isobaric), streamline, and isotach analysis and forecasting with emphasis on climatology, tropical cyclones, and meteorological satellite observations. PREREQUISITES: MR 3235, MR 3250 concurrently.

MR 3260 PROGNOSTIC CHARTS AND FORECASTING WEATHER ELEMENTS (3-0). Subjective and objective methods of prognosis, both for upper-air and surface circulations. Interpretation and alternation of computer-generated prognoses. Techniques for forecasting operationally-important weather elements. PREREQUISITES: MR 4323 or 3303 concurrently.

MR 3265 PROGNOSTIC CHARTS AND FORECASTING WEATHER ELEMENTS LABORATORY (0-6). Selected applications of prognostic methods discussed in MR 3260, to include manual modification of numerical prognoses. Practice in weather briefing to include diagnosis and forecasting of current weather situations using weather satellite observations and National Meterological Center and Fleet Numerical Weather Central products. PREREQUISITES: MR 3235; MR 3260 concurrently.

MR 3279 CASE STUDIES IN ENVIRONMENTAL SUPPORT (0-4). Laboratory experience in the application of oceanographical and meteorological analysis and prediction in support of naval strategy and tactics, emphasizing the planning, execution and situation analysis of naval operations from an environmental viewpoint. PREREQUISITES: OC 3616 and OC 3621 concurrently; and OC 3611, OC 3615, MR 3260 and MR 3265; or OC 4601, OC 3605, MR 3240 and MR 3245.

MR 3413 METEOROLOGY FOR OPERATIONAL SYSTEMS TECHNOLOGY (ASW) (4-0). A general course in meteorology for the Operational Systems Technology (ASW) curriculum. Atmospheric stability and motions are related by horizontal and vertical distributions of mass, temperature, and moisture; condensation processes and wind systems are related to synoptic models; boundary layer features are related to momentum exchange from the free atmosphere; fundamental consequences of air/sea interactions are related to boundary fluxes. PREREQUISITE: Differential and integral calculus and OC 2265.

MR 3420 GEOPHYSICAL THERMODYNAMICS (4-0). The physical variables; properties of gases, water and moist air; equations of state and the laws of thermodynamics applied to the atmosphere and oceans; entropy, adiabatic processes and potential temperatures; meteorological thermodynamic diagrams; geopotential and hydrostatic equilibrium, static and non-static instability criteria and phenomena. PREREQUISITE: MA 3132 concurrently.

MR 3421 CLOUD PHYSICS AND ATMOSPHERIC POLLUTION (3-1). Basic principles of cloud and precipitation physics and their applications to weather modification, suppression of hail and tornadoes, and suppression and enhancement of precipitation. Basic principles and theories of atmospheric pollution and the meteorological and ecological results of the changes in the natural atmosphere. PREREQUISITES: MR 3420, MA 3243.

MR 3520 ADVANCED CLIMATOLOGY (3-1). Spatial and temporal sampling of climatological and meteorological data. Statistical tools used in climatological and meteorological forecasts. Analysis of variance. Time series analysis. PREREQUISITE: MR 2520.

Graduate Courses

MR 4240 ADVANCED ATMOSPHERIC ANALYSIS (3-0). Advanced diagnostic techniques; vertical motion schemes including generalized omega equation and filtered vorticity and kinematic techniques; parcel dynamics along trajectories. Mesoscale analysis; application to severe storms and squall lines. Developments in atmospheric sensory systems; temperature profile determination and cloud motion from satellites, constant pressure balloons. PREREQUISITE: MR 4323.

MR 4242 ADVANCED TROPICAL METEOROLOGY (3-0). Equatorial wave theory; stratospheric wave motions and quasi-biennial oscillations; tropospheric disturbances; tropical boundary layer theories; cumulus convection parameterization; other dynamics and therdynamics of tropical flows. PREREQUISITES: MR 3250 or consent of Instructor.

MR 4250 GENERAL CIRCULATION OF THE ATMOSPHERE (3-0). Stability of zonal flows and implications for wave regimes; heat and momentum balances; mean meridional circulations; energetics of the general circulation; experimental models of the general circulation; implications for other rotating geophysical systems; trace substance transport by large scale atmospheric processes; numerical models of the general circulation. PREREQUISITE: MR 4323.

MR 4321 INTRODUCTORY GEOPHYSICAL FLUID DYNAMICS (4-0). Vectors and vector calculus; the hydrodynamical equations; scale analysis and simple gradient flows; pressure coordinates, thermal wind, baroclinity; friction and the planetary boundary layer; circulation and vorticity. PREREQUISITES: MA 2047, MA 2121, MR 3420.

MR 4322 DYNAMIC METEOROLOGY (4-0). Scale analysis, perturbation method; solutions of equations of motion for simple sound, gravity, and synoptic waves; filtering; baroclinic and barotropic instability; geostrophic adjustment. PREREQUISITE: MR 4321.

MR 4323 NUMERICAL WEATHER PREDICTION (4-3). Objective analysis, barotropic and baroclinic filtered and primitive equation models; vertical velocity; finite-difference equations; computational instability; boundary conditions; relaxation techniques, inclusion of heat, friction and moisture; energetics and general circulation models. PREREQUISITES: MR 4322, MA 3243 concurrently.

MR 4324 ADVANCED NUMERICAL WEATHER PREDICTION (3-0). Initialization, boundary conditions, finite difference schemes, stability and convergence; sensible, latent, and radiative heat transfer; simulation of sub-grid scale processes such as convection and friction; general circulation models, spectral methods. PREREQUISITE: MR 4323 or consent of Instructor.

MR 4331 ADVANCED GEOPHYSICAL FLUID DYNAMICS I (3-0). Dynamics of a homogeneous layer of fluid in a rotating system; scale analysis, dispersion and group velocity; barotropic and baroclinic instability—the discrete and the continuous spectrum of eigenvalues. PREREQUISITE: Consent of Instructor.

MR 4332 ADVANCED GEOPHYSICAL FLUID DYNAMICS II (3-0). Energetics of unstable disturbances, energy cascade; boundary layer analysis with application to the Ekman layer and ocean boundary currents; finite amplitude effects. PREREQUISITE: Consent of the Instructor.

MR 4412 HEAT TRANSFER PROCESSES (4-0). Monochromatic intensity and flux from black bodies; other properties of black bodies. The radiative transfer integral for flux crossing an arbitrary level in an atmosphere of water-vapor alone; of carbon-dioxide alone; the correction for overlap-effects when both are present. Terrestrial flux-divergence as cooling effect in the atmosphere. Solar insolation at the outer boundary of the atmosphere; at the ground; parameterization of extinction processes in the atmosphere. The albedo effects. The mean heat balance of the earth and atmosphere. Net radiative energy as a driving mechanism of the atmospheric motion systems. The Prandtl layer of constant eddy stress; of constant sensible-heat and water-vapor eddy-transfers near the earth's surface. PREREQUISITE: MR 4321 concurrently.

MR 4413 AIR/SEA INTERACTION (4-0). Consequences of momentum, heat and moisture exchange between atmosphere and ocean. Recent semiempirical formulae relating air/sea fluxes to large scale meteorological parameters. Concepts in turbulence and similarity theory for stationary turbulent regimes adjacent to the air/sea interface. Turbulence sensors, bulk aerodynamic formulae for estimating air/sea boundary fluxes. Mutual atmosphere and ocean response times and synoptic scale energy exchanges. Investigations of the role of the atmosphere and oceans to global energy balance and climate formation. PREREQUISITES: MR 4322, or OC 4252 and OC 3150 or consent of Instructor.

MR 4415 ATMOSPHERIC TURBULENCE (3-0). Approaches for defining the structure of the turbulent atmospheric boundary layer. Review of statistical descriptions of atmospheric turbulence; averaging, moments, joint moments, spectral representation. Equations for a turbulent regime in a stratified, shear flow. Scaling parameters and similarity theories for surface layer profiles, spectra: Kolmogorov hypotheses, Monin-Obukhov stability length. Measurement of atmospheric turbulence. Examination of observed spectra and scales of atmospheric turbulence. PREREQUISITE: MR 4322, MR 3520.

MR 4422 UPPER ATMOSPHERE PHYSICS (3-0). Composition, temperature, and wind above 30 km. Physics and chemistry of ozonosphere and ionosphere. Atmospheric tides, earth's magnetic field, air-glow. Van Allen belts. PREREQUISITE: MR 4412.

MR 4800 ADVANCED TOPICS IN ANALYSIS AND PREDICTION (3-0). Topics will be chosen to meet departmental and student needs. These topics may include geophysical fluid dynamics, tropical analysis and prediction systems, general circulation modeling of the air-ocean system, remote sensing. The course may be repeated for credit as topics change. PREREQUISITE: MR 4322 and consent of Department Chairman.

MR 4900 SEMINAR IN METEOROLOGY (0-2). Students present results of their thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper. Graded on Pass/Fail basis only.

The R/V ACANIA is used by students in the Oceanography curriculum

DEPARTMENT OF OCEANOGRAPHY

DALE FREDERICK LEIPPER, Professor of Oceanography; Chairman (1968)*; B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography (La Jolla), 1950; Hon. D.Sc., Wittenberg Univ., 1968.

ROBERT SANBORN ANDREWS, Assistant Professor of Oceanography (1968); B. of Geol. Engr., Univ. of Minnesota, 1958; M.S., Univ. of Washington, 1965; Ph.D., Texas A&M Univ., 1970.

LEROY ROBERT BECHELMAYR, Commander, U.S. Navy; Assistant Professor of Oceanography (1972); B.S., Naval Academy, 1955; M.S., Naval Postgraduate School, 1957.

NOEL EDWARD JAMES BOSTON, Associate Professor of Oceanography (1968); B.A.Sc., Univ. of British Columbia, 1959; M.S., Texas A&M Univ., 1963; Ph.D., Univ. of British Columbia, 1970.

ROBERT HATHAWAY BOURKE, Assistant Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

WARREN WILSON DENNER, Associate Professor of Oceanography (1964); B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963; Ph.D., 1969.

CALVIN RAY DUNLAP, Lieutenant Commander, U.S. Navy; Instructor in Oceanography (1973); B.S., Naval Academy, 1962; M.S., Naval Postgraduate School, 1968, M.A. Stanford Univ., 1971.

EUGENE CLINTON HADERLIE, Distinguished Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.D., 1950.

DAVID CROSBY HONHART, Lieutenant Commander, U.S. Navy; Instructor in Oceanography (1973); B.S., Naval Academy, 1963; M.S., Naval Postgraduate School, 1968.

GLENN HAROLD JUNG, Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas A&M Univ., 1955.

ROBERT GEORGE PAQUETTE, Associate Professor of Oceanography (1971); B.S., Univ. of Washington, 1936, Ph.D., 1941.

WARREN CHARLES THOMPSON, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

EDWARD BENNETT THORNTON, Associate Professor of Oceanography (1969); B.A., Willamette Univ., 1962; B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1965; M.E.C.E., Univ. of Florida, 1966; Ph.D., 1970.

EUGENE DEWEES TRAGANZA, Associate Professor of Oceanography (1970); B.A., Indiana Univ., 1955; M.S., Texas A&M Univ., 1959; Ph.D., Univ. of Miami, 1966.

STEVENS PARRINGTON TUCKER, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1972.

JOSEPH JOHN VON SCHWIND, Associate Professor of Oceanography (1967); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah at Salt Lake City, 1960; Ph.D., Texas A&M Univ., 1968.

JACOB BERTRAM WICKHAM, Associate Professor of Oceanography (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

Oceanography is the study of the sea from the points of view of the basic sciences: physics, biology, chemistry, and geology. The Department of Oceanography is the center for such studies at the Navy Postgraduate School. Its functions are to prepare officers to make best use of the ocean environment in the course of their duties, to prepare them to carry out and evaluate research in oceanography, and to carry out oceanographic research of both basic and/or applied nature.

The curriculum and research vessels are sponsored by the Oceanographer of the Navy. Research is supported by grants from various government agencies including the Office of Naval Research.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN OCEANOGRAPHY

BACHELOR OF SCIENCE WITH MAJOR IN OCEANOGRAPHY

1. The degree of Bachelor of Science with major in Oceanography requires completion of:
   a. A minimum of eleven quarter hours in upper division mathematics.
   b. Five quarter hours in meteorology.
   c. Four quarter hours in computer science.
   d. Twenty quarter hours in oceanography courses including descriptive, biological, chemical, and geological oceanography.
2. The entire sequence of courses selected must be approved by the Department of Oceanography.

MASTER OF SCIENCE IN OCEANOGRAPHY

Entrance to a program leading to the degree of Master of Science in Oceanography requires a baccalaureate degree in a field appropriate to the oceanography option chosen. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry.

The degree of Master of Science in Oceanography requires:

a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 Oceanography series. The entire sequence of courses for the particular option selected must be approved by the Department of Oceanography.

b. An acceptable thesis on a topic approved by the Department of Oceanography.

DOCTOR OF PHILOSOPHY

The Department of Oceanography considers for Ph.D. studies only students who have received their Bachelor's or Master's degree in one of the sciences or in engineering. Such students register for graduate work in the Department of Oceanography and comply with both department and school-wide requirements for the degree of Doctor of Philosophy. Their work is directed by an appropriate faculty member of the Department of Oceanography. On fulfilling the requirements they receive their degrees in oceanography with specialization in physical oceanography.

Because of the interdisciplinary nature of oceanography, under special circumstances, cooperative programs may be arranged with other departments. Several departments are including oceanography courses in their programs and are engaged on research projects related to the marine environment. Students wishing to participate in cooperative programs should indicate the direction of their interests so that the appropriate departments may be consulted.

Details of the requirements for admission to graduate study at the Naval Postgraduate School may be found elsewhere in this catalogue. The details of offerings in oceanography are in the latter part of this section.

Department of Oceanography admission requirements for the degree of Doctor of Philosophy are

(a) a Master's degree (or the equivalent)
or (b) a Bachelor's degree with a high QPR
or (c) a successful first graduate year on a Master's program, with clear evidence of research ability.

For the Ph.D. after the Master's, the program of study includes course work and preparation of a thesis embodying the results of original and independent research. The total amount of course work is determined by the candidate's committee and school requirements.

Candidates who are permitted to proceed to the Ph.D. directly from the Bachelor's degree must complete three quarters of course work of a minimum of 36 hours (approximately 9 courses) at the 4000 level, obtaining A's in at least 24 hours (6 course) and B's in the remaining.

Candidates must demonstrate competence in the English language and in such other languages as their committee recommends and the Naval Postgraduate School requires.

A student who desires to undertake doctoral work in oceanography should discuss his program first with the Chairman, Department of Oceanography. He should then consult the Curricular Officer for Environmental Sciences and follow regular guidelines as outlined by the Curricular Officer and the Academic Associate. A preliminary program will then be arranged. Following successful completion of the preliminary program a committee will be formed and a detailed program formulated.

LABORATORY FACILITIES

The department has two beachfront laboratories, a small biological oceanography laboratory with salt water aquaria and filtered salt water circulating system and a 4,000 square-foot laboratory with lecture room and student study areas. Equipment includes a wave tank, drying oven, and high pressure test chamber. Additionally, a small ocean engineering laboratory, chemical oceanography laboratory, and geological oceanography laboratory are maintained.

The School operates the R/V ACANIA, a 126-foot vessel, for use in oceanographic instruction and research. For approximately eight weeks each year use is made of AGOR vessels operated by the Naval Oceanographic Office for student indoctrination and for research by students and faculty.

Oceanographic equipment installed in the beach area includes wave and tide gauges for recording nearshore wave action and local tide fluctuations.

OCEANOGRAPHY

OC 0110 SEMINAR FOR OCEANOGRAPHY STUDENTS (0-0). Guest lecturers, trip reports, Navy career orientation, departmental research reviews. PREREQUISITES: None.

OC 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OC 2001 CONCEPTS OF ENVIRONMENTAL SCIENCE (4-0). Study will be made of environmental processes in both the atmosphere and the ocean that provide input to intelligence decision making. Sources of data, terminology and channels of data transmission will be discussed as well as the general reliability of environmental data. PREREQUISITE: None. May also be offered as SE 2001.

OC 2110 INTRODUCTION TO OCEANOGRAPHY (3-0). An introductory course treating physical and chemical properties of sea water, submarine geology, and marine biology; the heat budget of the oceans; water masses and general circulation; currents, waves, and tides. PREREQUISITE: None.

OC 2120 SURVEY OF OCEANOGRAPHY (4-0). Beginning physical oceanography, average values of ocean parameters, an integrated view of the whole field of oceanography including biological, geological, and chemical. PREREQUISITE: Calculus and college physics, or permission of Instructor.

OC 2420 PRINCIPLES OF MEASUREMENT (3-2). The application of the basic principles of mechanics, heat, electricity, sound and optics to oceanographic instrumentation employed by the Navy. Upper air and satellite developments; design and operation of oceanographic instruments; recording of oceanographic observations. PREREQUISITE: MA 2121.

OC 2430 ENVIRONMENTAL POLLUTION (3-0). A survey of air and water pollution theory and associated problems with specific case studies. Pertinent basic principles from oceanography and meteorology will be presented. PREREQUISITE: None. May also be offered as MR 2430.

Upper Division or Graduate Courses

OC 3150 GEOPHYSICAL RANDOM PROCESSES (4-2). Statistical evaluation of measurements in random media: ocean, atmosphere, earth; basic probability, probability distributions, probability density functions; random variables, random functions; harmonic analysis of random functions. Time series analysis:

covariance, convolution, energy density spectrum, cross spectrum. PREREQUISITES: MA 2121, MA 3232, MA 3132, and MR 2420 or OC 2420.

OC 3221 DESCRIPTIVE PHYSICAL OCEANOGRAPHY (4-0). Properties of sea water; distribution of temperature, salinity, and oxygen; heat budget of the oceans; water masses and the three-dimensional circulation of the oceans; currents, waves, and tides. PREREQUISITE: None.

OC 3250 DYNAMICAL OCEANOGRAPHY (4-0). Properties of sea water, the equations of motion in rotating frame of reference; special cases of motion; geostrophic, intertial, frictional flow, etc., turbulence and mixing; convection; models of general circulation; current measurements, direct and indirect. PREREQUISITES: MA 3132 concurrently; OC 3221.

OC 3260 SOUND IN THE OCEAN (3-0). Designed for students in the meteorology curricula. A brief introduction to physics of underwater acoustics followed by detailed discussion of oceanographic factors affecting sound transmission in the ocean including absorption, reflection from the surface and from the bottom, refraction, scattering, and ambient noise. PREREQUISITE: OC 2110 or OC 2120.

OC 3261 OCEANOGRAPHIC FACTORS IN UNDERWATER SOUND (4-0). This course examines the environmental factors which influence sound propagation in the ocean and the effects these factors have in acoustic forecasting. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, biological effects, reflection characteristics of ocean surface and bottom, signal fluctuations, and forecasting ocean thermal and sound speed structure. The students will review and report on related papers from the current literature. This course is designed for the Engineering Acoustics Curriculum. PREREQUISITES: OC 2120, PH 3452.

OC 3265 ENVIRONMENTAL FACTORS IN UNDERWATER ACOUSTICS (4-0). This course examines the environmental factors which influence sound propagation in the ocean. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, radiated noise, absorption, reflection characteristics of the sea surface and ocean bottom, signal fluctuations, and transmission loss models. The students will review and report on related papers from the current literature. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITES: OC 2120, MR 3413, PH 3471.

OC 3279 CASE STUDIES IN ENVIRONMENTAL SUPPORT (0-4). Laboratory experience in the application of oceanographical and meteorological analysis and prediction in support of Naval strategy and tactics, emphasizing the planning, execution and situation analysis of Naval operations from an environmental viewpoint. PREREQUISITES: OC 3620, OC 3611, OC 3615, MR 3260, and MR 3265 or OC 3610, MR 2200, and MR 2205.

OC 3320 GEOLOGICAL OCEANOGRAPHY (3-3). General geological principles; physiography of the sea floor, especially continental shelves and slopes, submarine canyons, coral reefs, and the deep-sea floor; properties and distribution of sediments and dates of deposition; structure and origin of the ocean basins; marine geophysics; field trips to local sites and aboard oceanographic research vessel. PREREQUISITE: None.

OC 3321 MARINE GEOPHYSICS (3-0). Gravity, magnetism seismicity, and other geophysical characteristics of the oceans and sea floor; physical properties and composition of the sea floor; structure of the earth's crust and upper mantle; origin of the ocean basins and formation of major sea-floor features. PREREQUISITE: OC 3320.

OC 3420 BIOLOGICAL OCEANOGRAPHY (3-3). General biological principles; the sea as an environment for life; major plant and animal groups in the sea; plankton and food cycles; primary productivity; boring and fouling organisms; bioacoustics, bioluminescence, and deep scattering layers; dangerous marine organisms; physiology of shallow water diving. Laboratory work and field trips dealing with marine organisms. PREREQUISITE: None.

OC 3520 CHEMICAL OCEANOGRAPHY (3-3). Basic chemistry of solutions; chemical compositions of the oceans (dissolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient, and other cycles in the sea; desalination; corrosion, geochemistry. PREREQUISITES: OC 3221, CH 1001 or CH 2001 or equivalent.

OC 3610 OCEAN WAVE FORECASTING (2-2). Prediction and observation of wind-generated ocean waves in deep water, interpretation of wave characteristics in spectral and statistical terms for operational briefings, and wave-related influences on operations. PREREQUISITES: OC 4211, OC 3150.

OC 3611 OCEAN WAVE AND SURF FORECASTING (2-0). Course designed for students in the meteorology curricula. Statistical and spectral properties of waves; wave observations and analysis of wave records; the generation, propagation and attenuation of sea and swell; techniques used in the forecasting of sea and swell; transformation of waves in shallow water. OC 2110 or OC 2120.

OC 3615 OCEAN WAVE AND SURF FORECASTING LABORATORY (0-4). Laboratory course taught in conjunction with OC 3611. Exercises in forecasting sea and swell generated under various synoptic weather conditions and in surf forecasting. PREREQUISITE: OC 3611 concurrently.

OC 3617 ACOUSTICAL FORECASTING FOR METEOROLOGISTS (2-2). Development of synoptic prediction techniques applied to the upper ocean and other environmental factors affecting underwater sound propagation. Current acoustical models, oceanographic input to the models and the tactical and strategic utilization of the output are described. Laboratory exercises illustrate principles developed during lectures. PREREQUISITE: OC 3260.

OC 3620 ACOUSTICAL FORECASTING (3-4). Development of synoptic prediction techniques applied to the upper ocean and other environmental factors affecting underwater sound propagation including air-sea interaction, advection, and mixing effects on the ocean density and sound speed structure. Current acoustical models, oceanographic input to the models and the tactical and strategic utilization of the output are described. Laboratory exercises illustrate principles developed during lectures. PREREQUISITES: OC 3260 or OC 4260.

OC 3625 ENVIRONMENTAL PREDICTION FOR UNDERWATER SOUND PROPAGATION (3-2). Development of synoptic prediction techniques applied to environmental factors affecting underwater sound propagation. These factors include space and time variation of ocean density structure and associated parameters, behavior of vertical and horizontal temperature gradients, air-sea interaction, advection and mixing effects on ocean density structure, and the generation, propagation, and decay of ocean waves. Current acoustic forecasting models will be studied in light of adequacy of environmental input data, realism, and computational approximations. This course is designed for the Operational Systems Technology (ASW) Program. PREREQUISITES: OC 2120, PH 2472, MR 3413.

OC 3709 SCIENTIFIC CRUISE EXPERIENCE (0-4). Laboratory course taught to introduce the student to oceanographic operations at sea. The use of standard oceanographic instruments

is stressed in the conduct of a comprehensive oceanographic survey; processing of data and storage of data and samples are studied and accomplished. Interpretation of results is introduced. PREREQUISITES: OC 2420 and OC 2110 or OC 2120 or OC 3221.

OC 3710 OCEANOGRAPHIC CRUISE PLANNING AND FIELD EXPERIENCE (2-4). This course gives comprehensive coverage of planning for oceanographic surveys and of interpretation and reporting of results. Included is a brief summary of hydrographic (charting) surveys. Field experience begun in OC 3709 is continued with students participating extensively in cruise planning. The cruise is scheduled for near mid-term; and after completion of at-sea operations, a report of survey is prepared. PREREQUISITES: OC 3709, OC 3320, OC 3420 and OC 3520 concurrently.

OC 3801 OCEAN OPERATIONS I (3-1). This course includes a comprehensive coverage of the present state-of-the-art associated with types of floating platforms; stationary platforms; submersible design, operation, and applications; manipulator design; diving operations; underwater construction and structures; energy sources; pressure vessels and testing programs; unmanned vehicles and platforms; deep drilling; dynamic positioning; buoys and deep water buoyancy; in general those operations associated with search, rescue, recovery, and salvage. Field trips made to laboratories deeply involved in oceanographic engineering work. PREREQUISITES: None.

OC 3901 BASIC HYDROGRAPHY (3-2). An introduction to the techniques used in hydrographic survey operations and nautical chart construction. Topics include vertical data planes, geodetic surveying, position fixing methods, echo sounders and depth corrections, and chart construction. Laboratory exercises illustrate principles developed during lectures. PREREQUISITES: OC 2110 or OC 2120, OC 3320.

Graduate Courses

OC 4211 WAVES AND TIDES (4-0). Linear theory of surface and internal waves; theory of finite amplitude waves; windwave spectra; theory of the astronomical tides; tide analysis and prediction; seiches and co-oscillations. PREREQUISITE: OC 4321 or MR 4321 or ME 2201.

OC 4213 COASTAL OCEANOGRAPHY (3-2). Shoal-water wave processes, breakers and surf; nearshore water circulations; beach characteristics; littoral drift; coastal hydraulics, storm tides. PREREQUISITE: OC 4211.

OC 4260 SOUND IN THE OCEAN AND ACOUSTIC MODELS (4-0). Oceanographic effects on sound propagation, especially on absorption, reflection, refraction; scattering, ambient noise; operational aspects for Navy use. PREREQUISITES: PH 3431 or equivalent and OC 3221.

OC 4321 INTRODUCTORY GEOPHYSICAL FLUID DYNAMICS (4-0). Development of the hydrodynamical equations, vector and tensor operations, forces acting on fluids (surface forces, body forces); stream function, velocity potential, geostrophic, gradient and inertial flows; baroclinic and barotropic fluids, vertical variation of horizontal velocity; Ekman spiral applied to ocean and atmosphere; geopotential surfaces, level of no motion; vorticity and divergence equations. PREREQUISITES: MA 2048 and MA 2121.

OC 4322 OCEAN DYNAMICS (4-0). The wind-driven ocean circulation, real fluid boundary conditions, steady-state linear theories, steady-state non-linear theories, vorticity arguments; topographical influence on ocean currents, significance of inertial and frictional terms in an ocean with bottom topography; time dependent motion, Rossby waves. PREREQUISITE: OC 4321.

OC 4323 HYDROTHERMODYNAMICS (3-0). Development of the fundamental equations of hydrothermodynamics as applied to seawater; conservation of total energy, first and second laws of thermodynamics for fluid mixtures, entropy; equation of state for seawater; transport phenomena, special laws of non-advective transfer of properties. PREREQUISITE: OC 4322.

OC 4413 AIR-SEA INTERACTION (3-0). Consequences of momentum, heat and moisture exchange between atmosphere and ocean; recent semi-empirical formulae relating air-sea fluxes to large-scale meterological parameters; concepts in turbulence and similarity theory for stationary turbulent regimes adjacent to the air-sea interface; turbulence sensors, bulk aerodynamic formulae for estimating air-sea boundary fluxes; mutual atmosphere and ocean response times and synoptic scale energy exchanges; investigations of the role of the atmosphere and oceans of global energy balance and climate formation. PREREQUISITES: OC 3150, OC 4322 or MR 4322, or consent of Instructor.

OC 4421 MARINE ECOLOGY (1-4). The habits, classification, development and adaptations of marine animals and plants with particular reference to ecology of Monterey Bay. The relationships of physical, chemical, geological, and biological factors of the environment to marine organisms. Primarily laboratory investigations and field work dealing with the intertidal areas, harbors, estuaries, and the near-shore pelagic and benthic environments of the associated organism. PREREQUISITE: OC 3420.

OC 4422 MARINE BIODETERIORATION (1-1). A study of the organisms involved in the bio-deterioration of engineering materials. Subjects included are marine fouling, wood and rock borers, and the effects of biological organisms on the corrosion of metals. PREREQUISITE: OC 3420.

OC 4612 POLAR OCEANOGRAPHY (3-2). Oceanographic and geophysical structure of the polar regions; sea-ice properties, formation, growth, deformation and disintegration; sea-ice drift due to wind and currents. The course is frequently conducted as a two-week course with field experience at the Naval Arctic Research Laboratory, Barrow, Alaska. Laboratory studies of the physical, chemical, petrographic structure and strength properties of ice are conducted. PREREQUISITE: None.

OC 4800 SPECIAL TOPICS IN OCEANOGRAPHY (1-0 to 4-0). Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the Department Chairman and Instructor.

OC 4802 OCEAN OPERATIONS II (3-1). Considerations of more complex aspects of oceanographic engineering operations, including such subjects as deep mooring techniques; platform and ship motions; large object towing forces; heavy lifts and line dynamics; wave loads on platforms and floating breakwaters; hydrodynamic aspects of falling objects; considerations of high pressure structural design; participation in a laboratory exercise involving conducting an oceanographic engineering operation at sea. PREREQUISITE: OC 3801.

OC 4803 PHYSICAL PROPERTIES OF MARINE SEDIMENTS (2-3). This course involves the elementary study of the physical behavior of marine sediments including such subjects as types of sediments, coring and testing equipment, general physical characteristics of sediments, methods of detailed physical and chemical analysis, in-situ testing, pressure effects, scour and fill, turbidity flows. Application is made to penetration and breakout of objects and to trafficability. PREREQUISITE: OC 3320.

OC 4860 PHYSICS OF THE EARTH (3-0). Physical properties and composition of the earth's interior; review of the theories of the earth's formation; study of the crustal structure through gravity, magnetic, seismic, and other geophysical evidence. PREREQUISITE: OC 3320 or consent of the Instructor.

OC 4900 SEMINAR IN OCEANOGRAPHY (2-0). Students in the various oceanography curricula report results of their own research in presentations for group discussion. PREREQUISITE: Preparation of a thesis or a research paper concurrently.

OPERATIONAL SYSTEMS TECHNOLOGY

The Operational Systems Technology Group has administrative responsibility for the academic content of the Operational Systems Technology (ASW) Program. Teaching in this program is carried out by faculty members attached to the various Academic Departments associated with the Program.

WILLIAM PEYTON CUNNINGHAM, Distinguished Professor of Physics and Operations Research; Chairman (1946)*; B.S., Yale Univ., 1928; Ph.D., 1932.

GEORGE JOSEPH HALTINER, Distinguished Professor and Chairman of the Meteorology Department (1946); B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

CARL RUSSELL JONES, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

WARREN CHARLES THOMPSON, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

CARROLL ORVILLE WILDE, Associate Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); B.S., Univ. of Texas, 1944; MA., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

DEGREE REQUIREMENT MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:

   a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included and in three disciplines, a course at the 4000 level must be included.

   b. An approved sequence of at least three courses constituting advanced specialization in an option area must be included.

   c. In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.

   d. The program must be approved by the Chairman of the appropriate Operational Systems Technology Academic Committee.

SYSTEMS TECHNOLOGY

ST 0001 SEMINAR (0-1). Special lectures, and discussion of matters related to the Operational Systems Technology (ASW) Programs. PREREQUISITE: SECRET Clearance.

ST 0810 THESIS RESEARCH/GROUP PROJECT (0-0). Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

Upper Division or Graduate Courses

ST 3000 STUDY PROJECT ON ASW SYSTEMS PERFORMANCE (0-2). This project is the study and analysis of the performance of an assigned type of ASW system under a variety of realistic operating conditions. Graded on a Pass/Fail basis. PREREQUISITE: Enrollment in Operational Systems Technology (ASW) curriculum or consent of curriculum coordinator, SECRET clearance.

ST 3180 ELECTROMAGNETIC WAVE PROPAGATION (4-2). A course designed for the Operational Systems Technology (ASW) curriculum. An introduction to basic properties of electromagnetic wave propagation and the phenomena of radio and radar transmission. Topics will include EM field theory, antennas, propagation, communication and radar systems. PREREQUISITES: EE 2721, PH 2472, MA 3139, and vector analysis.

ST 3181 NON-ACOUSTIC SENSOR SYSTEMS (4-0). A course for the Operational Systems Technology (ASW) curriculum. The purpose is to expose the technology and engineering of various systems important in anti-submarine warfare operations which involve non-acoustic sensing methods. Systems to be discussed include passive and active electronic warfare. Echo ranging, field distortion, image systems, communication and telemetry, proposed systems. The systems approach implies a consideration of environmental effects. PREREQUISITES: EE 2721, ST 3180, EE 3714, SECRET Clearance.

ST 3340 THE DEFENSE DECISION PROCESS AND ASW WARFARE (4-0). Study of the defense decision process as it relates to the choice of ASW forces. This overview course includes consideration of the systems acquisiton system, the planning, programming and budgeting system, and their interrelationship in setting the ASW force level and mix. The effect of the Office of Management and Budget and the congressional budget deliberation process on ASW forces is also considered. Specific techniques and ideas discussed include threat, deterrence, net assessment, costs and costing, effectiveness models, and cost-effectiveness analysis. Applicable DoD and Navy documents are introduced. PREREQUISITE: Last quarter standing in the Operational System Technology (ASW) curriculum.

ST 3390 COMPUTATION AND COMPUTER SIMULATION (4-2). Programming in FORTRAN and specialized simulation languages, with applications to the solution of ASW problems by simulation. Designed for students in the Operational Systems Technology (ASW) curriculum. PREREQUISITE: CS 2501.

DEPARTMENT OF OPERATIONS RESEARCH AND ADMINISTRATIVE SCIENCES

DAVID ALAN SCHRADY, Associate Professor of Operations Research; Chairman (1965)*; B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

DONALD LEWIS ABBEY, Lieutenant Commander, U.S. Navy; Instructor in Operations Research (1972); B.S., United States Naval Academy, 1963; M.S., Naval Postgraduate School, 1968.

ALVIN FRANCIS ANDRUS, Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

JAMES KENICHI ARIMA, Associate Professor Operations Research and Behavioral Science (1969); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

RONALD STEPHENS BARDEN, Lieutenant, U.S. Naval Reserve; Assistant Professor Accounting and Information Systems (1971); B.S., Univ. of North Carolina, 1968; Ph.D., Univ. of Texas, 1971.

DONALD ROY BARR, Associate Professor of Operations Research and Statistics (1966); B.A., Whittier College, 1960; M.S., Colorado State Univ., 1962; Ph.D., 1965.

ROBERT JO BEDOW, Lieutenant Commander, U. S. Navy; Instructor in Operations Research (1971); B.S., Univ. of California at Berkeley; M.S., Naval Postgraduate School, 1967.

PHILIP WRENN BENEDIKTSSON, Commander, U. S. Navy; Instructor in Management (1973); B.S., Univ. of South Carolina, 1956; M.S., Naval Postgraduate School, 1972.

MICHAEL KENT BLOCK, Associate Professor of Economics (1972); B.A., Stanford Univ., 1964; M.A., 1969; Ph.D., 1972.

DAN CALVIN BOGER, Lieutenant, U. S. Navy; Instructor in Economics and Operations Research (1973); B.S., Univ. of Rochester, 1968; M.S., Naval Postgraduate School, 1969.

GORDON HOOVER BRADLEY, Associate Professor of Administrative Sciences (1973); B.S., Lehigh Univ., 1962; M.S., 1964; Ph.D., Northwestern Univ., 1967.

EDWARD ABE BRILL, Assistant Professor of Operations Research (1970); A.B., Univ. of California at Los Angeles, 1966; M.S., Stanford Univ., 1967; Ph.D., 1970.

GERALD GERARD BROWN, Ensign, U. S. Navy; Assistant Professor of Administrative Sciences (1973); B.A., California State Univ. at Fullerton, 1968; M.B.S., 1969.

THOMAS DANFORTH BURNETT, Assistant Professor of Operations Research and Statistics (1969); B.S., Oregon State Univ., 1962; M.S., 1964; Ph.D., 1969.

DAVID CARLO BURNS, Assistant Professor of Accounting and Management (1972); B.B.A., Univ. of Cincinnati, 1968; M.B.A., Indiana Univ., 1970; D.B.A., 1972.

RICHARD WESLEY BUTTERWORTH, Associate Professor of Operations Research, (1969); B.S., Univ. of California at Berkeley, 1966; M.S., 1967; Ph.D., 1969.

JAMES ROBERT CAPRA, Lieutenant, U. S. Naval Reserve; Instructor in Operations Research (1970); B.A., Georgetown Univ., 1968; M.S., Naval Postgraduate School, 1970.

PAUL MARSHALL CARRICK, Associate Professor of Management (1969); B.A., Northwestern Univ., 1949; Ph.D., Univ. of California at Berkeley, 1956.

WILLIAM HOWARD CHURCH, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

JOHN WALLIS CREIGHTON, Professor of Management (1967); B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

WILLIAM PEYTON CUNNINGHAM, Distinguished Professor of Physics and Operations Research (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

LESLIE DARBYSHIRE, Professor of Management (1962); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

STANLEY MICHAEL DEAN, Assistant Professor of Management (1973); B.A., Brigham Young Univ., 1962; M.B.A., Harvard Univ., 1964. D.B.A., 1974.

PETER DEMAYO, Commander, U. S. Navy; Assistant Professor of Management (1972); B.S., Hofstra College, 1958; M.B.A., Univ. of Michigan, 1965.

RICHARD SANFORD ELSTER, Associate Professor of Management and Psychology (1969); B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D., 1967.

CARSON KAN EOYANG, Assistant Professor of Management (1974); B.A., Massachusetts Institute of Technology, 1966; M.B.S., Harvard Univ., 1968; Ph.D., Stanford Univ., 1974.

JAMES DANIEL ESARY, Professor of Operations Research and Statistics, (1970); A.B., Whitman College, 1948; M.A., Univ. of California at Berkeley, 1951; Ph.D., 1957.

ROBERT NEAGLE FORREST, Associate Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

JAMES MORGAN FREMGEN, Professor of Accounting (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

DONALD PAUL GAVER, JR., Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

WILLIAM CANNON GIAUQUE, Assistant Professor of Administrative Sciences (1973); B.S., California Institute of Technology, 1963; M.B.A., Harvard Univ., 1968; D.B.A., 1972.

WILLIAM JAMES HAGA, Assistant Professor of Management (1972); B.B.A., Wayne State Univ., 1960; M.A., Univ. of Illinois, 1970; Ph.D., 1972.

JAMES KERN HARTMAN, Associate Professor of Operations Research (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

FENN CLARK HORTON, Associate Professor of Economics (1964); B.A., State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., 1968.

GILBERT THOREAU HOWARD, Associate Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

JAMES PATRICK HYNES, Assistant Professor of Administrative Sciences (1969); B.A., Univ. of Notre Dame, 1966; M.B.A., Michigan State Univ., 1967; Ph.D., 1971.

RUSSELL EDWIN JAMISON, Lieutenant Colonel, U. S. Marine Corps; Instructor in Management (1972); B.S., Univ. of Maryland, 1962; M.S., Naval Postgraduate School, 1972.

JAMES ALVIN JOLLY, Associate Professor of Administrative Sciences (1969); B.A., Univ. of the Pacific, 1950; M.B.A., Univ. of Santa Clara, 1963; Ph.D., 1970.

CARL RUSSELL JONES, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

ROBERT RUSSELL JUDSON, Adjunct Professor of Management (1973); B.A., Univ. of Illinois, 1951; M.S., 1955.

MELVIN BERNARD KLINE, Professor of Management (1970); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

HAROLD JOSEPH LARSON, Professor of Operations Research and Statistics (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

PETER ADRIAN WALTER LEWIS, Professor of Operations Research and Statistics (1971); B.A., Columbia College, 1954; B.S., Columbia Engineering School, 1955; M.S., 1957; Ph.D., Univ. of London, 1964.

GLENN FRANK LINDSAY, Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

ALAN WAYNE MCMASTERS, Associate Professor of Operations Research (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

KNEALE THOMAS MARSHALL, Associate Professor of Operations Research (1968); B.Sc., Univ. of London, 1958; M.S., Univ. of California at Berkeley, 1964; Ph.D., 1966.

PAUL ROBERT MILCH, Associate Professor of Operations Research and Statistics (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

GERALD LEE MUSGRAVE, Assistant Professor of Administrative Sciences (1968); B.A., California State Univ.—Northridge, 1964; M.S., Michigan State Univ., 1966; Ph.D., 1972.

DOUGLAS ELMER NEIL, Assistant Professor of Operations Research (1972); B.A., Univ. of Southern California, 1965; M.S., Univ. of Pacific, 1967; Ph.D., North Carolina State Univ., 1971.

SAMUEL HOWARD PARRY, Assistant Professor of Administrative Sciences (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

CLAIR ALTON PETERSON, Associate Professor of Operations Research and Economics (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

GARY KENT POOCK, Associate Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., University of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

WILLIAM MICHAEL RAIKE, Associate Professor of Operations Research (1971); B.A., Northwestern Univ., 1964; M.S., 1965; Ph.D., 1967.

ROBERT RICHARD READ, Professor of Operations Research, Probability and Statistics (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

FRANCIS RUSSELL RICHARDS, Assistant Professor of Operations Research (1970); B.S., Louisiana Polytechnic Institute, 1965; M.S., Clemson Univ., 1967; Ph.D., 1971.

NORMAN FLOYD SCHNEIDEWIND, Professor of Information Systems (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR.), 1970; D.B.A., 1966.

JAMES FREDRICK SCHUMANN, Commander, CEC, U.S. Navy; Instructor in Management (1972); B.S., Univ. of California at Berkeley, 1955; M.S., Naval Postgraduate School, 1972.

JOHN DAVID SENGER, Associate Professor of Management and Behavioral Sciences (1967); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

BRUNO OTTO SHUBERT, Associate Professor of Operations Research (1970); M.S., Czechoslovakia Technical Univ. at Prague, 1960; Ph.D., Charles Univ. at Prague, 1964; Ph.D., Stanford Univ., 1968.

REX HAWKINS SHUDDE, Associate Professor of Operations Research (1962); B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

MICHAEL GRAHAM SOVEREIGN, Associate Professor of Operations Research (1970); B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

GEORGE LAWRENCE STANSBURY, Commander, U. S. Navy; Assistant Professor of Management

(1972); B.S., Florida Southern College, 1951; M.S., Naval Postgraduate School, 1963.

ROBERT ARMAND STEPHAN, Commander, U. S. Navy; Assistant Professor of Operations Research (1972): B.S., Naval Postgraduate School, 1965; M.S., 1967.

THOMAS NEAL TATE, Commander, CEC, U. S. Navy; Instructor in Management (1972); B.S., U. S. Naval Academy, 1955; B.C.E., Rensselaer Polytechnic Institute, 1957; M.S., Stanford Univ., 1966.

JAMES GROVER TAYLOR, Associate Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

KATSUAKI TERASAWA, Assistant Professor of Economics (1972); B.A., Univ. of Washington, 1967; Ph.D., Univ. of Kansas, 1972.

MARLIN ULUESS THOMAS, Assistant Professor of Operations Research (1971); B.S., Univ. of Michigan, 1967; M.S.E. 1968; Ph.D., 1971.

JOSEPH BRYCE TYSVER, Associate Professor of Operations Research and Statistics (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

ALAN ROBERT WASHBURN, Assistant Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

BERT REED WEBSTER, Lieutenant Commander, U. S. Navy; Instructor in Operations Research (1972); B.S., Utah State Univ., 1960; M.S., Iowa State Univ., 1962; M.S., Naval Postgraduate School, 1970.

RONALD ALFRED WEITZMAN, Associate Professor of Psychology (1971); B.A., Stanford Univ., 1952; M.A., 1954; Ph.D., Princeton Univ., 1959.

DAVID RICHARD WHIPPLE, JR., Associate Professor of Operations Research and Economics (1971); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

CHESTER ARTHUR WRIGHT, Adjunct Professor of Social Psychology (1973); B.A., San Francisco State Univ., 1965; M.S., Univ. of California at Los Angeles, 1968.

THOMAS ANDREW WYATT, Assistant Professor of Psychology (1972); B.A., Univ. of Victoria; M.A., Univ. of New Hampshire, 1967; M.B.A., Univ. of California at Berkeley, 1968; Ph.D., 1973.

EDWARD ANDREW ZABRYCKI, Lieutenant Commander, U.S. Naval Reserve; Instructor in Management (1972); B.S., U. S. Naval Academy, 1956; M.B.A., Ohio State Univ., 1971.

PETER WILLIAM ZEHNA, Professor of Operations Research and Statistics (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956; Ph.D., Stanford Univ., 1959.

HANS JACOB ZWEIG, Associate Professor of Operations Research and Statistics (1970); B.A., Univ. of Rochester, 1949; M.A., Brown Univ., 1952; Ph.D., Stanford Univ., 1963.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Operations Research and Administrative Sciences.

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

1. The basic requirements for the degree of Bachelor of Science in Operations Research consists of a minimum of 60 upper division quarter hours at the Naval Postgraduate School and including at least:

a. 36 quarter hours of operations research systems analysis and probability and statistics.
b. 12 quarter hours outside the Department of Operations Research and Administrative Sciences.

2. The student must maintain a QPR of at least 2.2 in courses offered by the Department of Operations Research and Administrative Sciences.

MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

1. A candidate for the degree of Master of Science in Computer Systems Management must complete satisfactorily either (A) a minimum of 56 quarter hours of graduate level course work or (B) a minimum of 48 quarter hours of graduate level course work and an acceptable thesis.

2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Computer Science
Data Processing
Economics
Financial Management and Accounting
Material Management
Operations Research
Statistics

MASTER OF SCIENCE IN MANAGEMENT

The award of the degree of Master of Science in Management requires:

1. Completion of the Management Fundamentals program plus a minimum of eight (8) quarter hours of upper division courses in subjects directly pertinent to the nature and objectives of the particular curriculum. The Management Fundamentals program consists of a total of 34 quarter hours of 2000 and 3000 level courses, including a minimum of the following hours by disciplines:

Accounting and Financial Management	6
Behavioral Science	3
Economics	6
Management Theory	3
Quantitative Methods	8

2. The completion of a minimum of forty (40) quarter hours of graduate level courses, at least twelve (12) quarter hours at the 4000 level.

3. The completion of an approved sequence of courses in the student's area of concentration. Ex-

amples of concentration areas are accounting and financial management, communications management, economics, management science, material management, personnel management, and systems acquisition management.

4. In addition to the 40 quarter hours of course work, the submission of an acceptable thesis on a topic previously approved by the Department of Operations Research and Administrative Sciences.

5. Final approval of a program leading to the Master of Science in Management shall be obtained for each student from the Chairman, Department of Operations Research and Administrative Sciences.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate-level courses, including at most 8 quarter hours for a thesis.

a. At least 18 quarter hours of 4000 level operations research/systems analysis courses.
b. An elective sequence approved by the Department of Operations Research and Administrative Sciences.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Research and Administrative Sciences. This credit shall not count toward the requirement stated in 2a.

DOCTOR OF PHILOSOPHY

1. Students currently enrolled in the Master of Science program and who wish to be considered for doctoral work in Operations Research should announce their intentions as early as possible, preferably by the fifth quarter. The department chairman will examine the applicant's qualifications, modify his second year program, and monitor his progress. The schoolwide requirements are contained in the General Information section of this catalogue.

2. Students wishing to enter directly into the doctoral program should write to the department chairman. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases the student must fulfill the schoolwide requirements contained in the General Information section of this catalogue.

3. If the applicant is selected, he must pursue a course of in-depth study in mathematical programming, stochastic processes and a third area approved by his doctoral committee. He must be advanced to candidacy and write an acceptable thesis pertinent to an area of specialization selected from the following four: stochastic processes, mathematical programming, decision sciences, and human factors.

COMMUNICATIONS MANAGEMENT

CM 0001 SEMINAR FOR COMMUNICATIONS MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

CM 0810 THESIS RESEARCH FOR COMMUNICATIONS MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division or Graduate Courses

CM 3184 REAL-TIME INFORMATION SYSTEMS (4-0). The study of real-tine and on-line information systems from a functional and management standpoint. Topics covered are: the characteristics, effectiveness and system economics of selected DOD and civilian computer-communication networks and services; management of real-time system development and operations and analytical tools for evaluation of real-time systems. PREREQUISITES: CS 2103, MN 3105, MN 3210.

CM 3210 OPERATIONS RESEARCH FOR COMMUNICATIONS MANAGERS (4-0). A one-quarter survey of operations research techniques of particular interest to students in communications management. Model formulation, decision theory, games, linear programming, network flows, CPM and PERT, reliability and maintainability, queueing theory, and systems simulation. PREREQUISITES: MA 2300, PS 3000.

Graduate Course

CM 4184 REAL-TIME INFORMATION SYSTEM MANAGEMENT (4-0). This course, given in the final quarter of the Communications Management curriculum, integrates material presented in previous courses. Cases and examples are considered which are illustrative of the management problems confronting a communications manager in naval communication station or headquarters communications development activities. PREREQUISITES: CM 3184, EE 3425.

COMPUTER SYSTEMS MANAGEMENT

CT 0001 SEMINAR FOR COMPUTER SYSTEMS MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

CT 0810 THESIS RESEARCH FOR COMPUTER SYSTEMS MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will renroll in this course.

Upper Division or GRADUATE Course

CT 3210 OPERATIONS RESEARCH FOR COMPUTER SYSTEMS MANAGERS (4-0). A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Model formulation, decision theory, linear programming, project management techniques, inventory models, queueing and simulation, reliability and maintainability. Examples will illustrate the application of these techniques to the management of computer systems. PREREQUISITES: MA 2300, PS 3011, and PS 3012.

Graduate Courses

CT 4182 DATA PROCESSING MANAGEMENT (4-0). Study of computer systems analysis and design. Management of ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: feasibility studies, selection, and acquisition of equipment; evaluation of computer hardware and software; installation and effective utilization of ADP equipment; and various types of computer applications. PREREQUISITE: CS 2100 or equivalent.

CT 4185 COMPUTER-BASED MANAGEMENT INFORMATION SYSTEMS (4-0). The application and design of computer-based information systems for management planning, control and operations. This is a required course in the computer Systems Management Curriculum and also is offered as an elective for

other students who have taken the course prerequisites. PREREQUISITES: CS 2103, MN 3155 or equivalent, and CT 3210 or equivalent.

MANAGEMENT

MN 0001 SEMINAR FOR MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

MN 0810 THESIS RESEARCH FOR MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

MN 2030 INTRODUCTION TO ECONOMICS (4-0). Survey of the methodology of economics and its application to such problems as economic development, employment, inflation, industrial organization, consumer behavior and defense economics. PREREQUISITE: None.

MN 2031 ECONOMIC DECISION MAKING (4-0). The macroeconomic section includes a presentation of methods of national income determination, the consumption function and multiplier concepts and the impact of fiscal and monetary policies. The microeconomic section covers an introduction to individual economic decision processes and their relation to attainment of market equilibria. PREREQUISITE: MA 2305 concurrently.

MN 2106 INDIVIDUAL AND GROUP BEHAVIOR (4-0). A survey of individual and group behavior with emphasis on those aspects which affect performance and satisfaction within an organization. Topics include motivation, learning, personality, leadership, group effectiveness and role behavior. PREREQUISITE: None.

MN 2150 FINANCIAL ACCOUNTING (4-0). Study of the basic postulates and principles of accounting. Specific topics include the accounting cycle, asset valuation, equities and capital structure, financial statement analysis, and elementary cost accounting. PREREQUISITE: None.

MN 2155 SELECTED TOPICS IN ACCOUNTING AND FINANCIAL MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics of special interest. This course may be repeated for credit if course content changes. PREREQUISITE: A background in accounting and financial management and Departmental approval.

MN 2970 LOGISTICS MANAGEMENT (4-0). Military logistics processes and the organization of the Navy for logistics administration including: the planning-programming-budgeting cycle, budget development and execution, procurement, and hardware development. PREREQUISITE: None.

Upper Division or Graduate Courses

MN 3001 BEHAVIORAL RESEARCH METHODOLOGY (4-0). Introduction to epistomology and the philosophy of science. Hypothetical constructs, intervening variables and operational definitions will be discussed. An introduction to measurement and scaling will be given. Uses of inferential statistics and experimental method, both in the laboratory and in the field, will be examined. PREREQUISITES: MN 3105, MN 3211, and MN 3212 (concurrently).

MN 3101 PERSONNEL MANAGEMENT AND LABOR RELATIONS (4-0). Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development and current status of labor-management relations in industry and government. Analysis of the labor market and the implications of government regulations for wages and labor-management bargaining. PREREQUISITES: MN 3105, MN 3140, and MN 3161.

MN 3105 ORGANIZATION AND MANAGEMENT (4-0). The study of the management of organizations emphasizing human and organizational variables and their implications for managerial action. Topics include the theories of management, organizational behavior, planning and control, and organizational development. PREREQUISITE: MN 2106.

MN 3110 INDIVIDUAL BEHAVIOR (4-0). Study of the basic characteristics and determinants of individual behavior. Specific topics include personality, motivation, learning, behavior conditioning, and introduction to tests and measurement. Implications for effective administrative practice. PREREQUISITE: MN 3105.

MN 3111 INDUSTRIAL PSYCHOLOGY (4-0). A broad coverage of human behavior in the work situation with special emphasis on the problem of work in the Naval environment. Topical areas covered include selection, placement, training, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in organizations; equipment design and man-machine relationships; and consumer (user) behavior and the impact of technological programs. PREREQUISITES: MN 3105, MN 3212 (concurrently).

MN 3112 SELECTED TOPICS IN HUMAN RESOURCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3120 PLANNING AND CONTROL (4-0). Theory and techniques of the management functions of planning and control. Topics will include policy and strategy formulation, long- and short-range planning, goal-setting and management by objectives, budgeting and forecasting, performance evaluation and the use of rewards. PREREQUISITE: MN 3105 and MN 3161.

MN 3121 LEADERSHIP AND GROUP BEHAVIOR (4-0). The study of groups in different settings and factors affecting both individual and group behavior. Attention will be given to such concepts as authority, conformity, cohesiveness, effectiveness, and leadership. Emphasis will be placed on methods of observing group action. PREREQUISITE: MN 3105.

MN 3122 COMPARATIVE CULTURES (4-0). A comparative look at organization structures, management philosophies, and supervisory techniques around the world. This cross-cultural analysis is prefaced by an introduction to the analysis of culture and social systems. Particular attention will be given to the problems of management in traditional societies undergoing modernization. PREREQUISITE: MN 3105.

MN 3123 SOCIOLOGICAL ANALYSIS (4-0). Survey of the general principles of the sociological perspective in a symbolic interaction frame work. Emphasis on processes and concepts including social interaction, aggregates, authority, roles, status, norms, culture, alienation, deviance, and the nature of social change. PREREQUISITE: MN 3105.

MN 3124 ANALYSIS OF BUREAUCRACY (4-0). An analysis of the forms and processes of complex organizations in evolution from charisma to bureaucracy. Topics include formal dimensions of structure, informal structure, professionalism, basic growth and elaboration processes, and applications of general systems theory to organizational phenomena. PREREQUISITE: MN 3105.

MN 3125 ORGANIZATIONAL BEHAVIOR AND ADMINISTRATION (4-0). Analysis of human situations and their administrative implications. The course focuses on the responses made by individuals and groups to the influences bearing upon their behavior in organizational settings. PREREQUISITE: MN 3105.

MN 3126 SELECTED TOPICS IN THE BEHAVIORIAL SCIENCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3127 SELECTED TOPICS IN ORGANIZATION AND MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3130 MACROECONOMIC THEORY (4-0). Development of models to analyze the relationships between aggregate consumption, investment and output. Consideration of debt and financial assets, technical progress, growth, and monetary and fiscal control systems. PREREQUISITES: MN 2030 or MN 2031.

MN 3135 SELECTED TOPICS IN ECONOMICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in economics and Departmental approval.

MN 3140 MICROECONOMIC THEORY (4-0). Determination of the allocation of resources and the composition of output. Consumer and Producer Choice Theory. Partial and general equilibrium analysis. Welfare economics. Applications to defense problems are emphasized. PREREQUISITES: MN 2031, MA 2305, and MA 2040 or their equivalents.

MN 3141 MICROECONOMICS (4-0). Study of the allocation of scarce resources to competing goals. Consumer behavior and utility theory. Theory of the firm. Analysis of alternative market structures. PREREQUISITE: MN 2030.

MN 3142 INTERNATIONAL TRADE AND DEVELOPMENT (4-0). Study of the nature of trade between nations and the various approaches to economic development. Topics include trade and resource allocation, international finance, growth and development theory, and the market-public planning for development debate. Policy issues are considered with emphasis on the implications for national action. PREREQUISITES: MN 3130, MN 3140 or MN 3141.

MN 3143 MANAGERIAL ECONOMICS (4-0). Microeconomic theory and its applications and capital budgeting; significance of market structure upon performance, investment decisions and capital budeting. Case and Industry studies. PREREQUISITE: MN 2030 or equivalent.

MN 3146 COMPARATIVE ECONOMIC SYSTEMS (4-0). The characteristics and functions of economic systems. Criteria for evaluating performance. The analysis of alternative patterns of control, planning and market structures under capitalism, socialism, and mixed economies. PREREQUISITE: MN 2030.

MN 3152 MANAGERIAL FINANCE (4-0). The study of corporation financing and financial management from the point of view of the company, the investor and capital market operations. Topics considered include capital structure, dividend policy, short-intermediate-long term financing, current asset management and asset investment choice. Consideration of government contractor financial problems. PREREQUISITES: MN 3140, MN 3161, MN 3211 (concurrently).

MN 3155 FINANCIAL AND MANAGERIAL ACCOUNTING (4-0). Study of both financial and managerial accounting. Introduces the accounting principles, practices and procedures associated with modern integrated systems. Specific topics include the accounting cycle, asset valuation, equities, capital, financial statement analysis, flexible budgets, cost volume profit analysis, and capital budgeting. *Closed to all students who must take MN 2150 and/or MN 3161.* Does not meet prerequisite requirement for financial management elective courses. PREREQUISITE: None.

MN 3161 MANAGERIAL ACCOUNTING (4-0). Survey of cost accounting systems, including overhead costing, job order and process cost systems, variable and absorption costing, and standard costs. Emphasis is on applications of accounting data to planning, control and decision making. Topics covered include flexible budgets, variance analysis, cost-volume-profit analysis, and incremental profit analysis. Capital budgeting is examined extensively. PREREQUISITE: MN 2150.

MN 3165 SELECTED TOPICS IN ACCOUNTING AND FINANCIAL MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in accounting and financial management and Departmental approval.

MN 3170 DEFENSE RESOURCE ALLOCATION (4-0). The study of the process by which resources are allocated with the Department of Defense. Topics include an analysis of the planning, programming, and budgeting system and the systems acquisition process, cost-effectiveness analysis, and the economic, social and political environment of the military manager. PREREQUISITES: Financial and Managerial Accounting, Microeconomics or Managerical Economics, and a survey of operations research/system analysis.

MN 3172 PUBLIC POLICY PROCESSES (4-0). A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May also be offered as GV 3172.

MN 3183 MANAGEMENT INFORMATION SYSTEMS AND THE COMPUTER (4-0). Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in computer-based and other information systems. Study of basic computer and MIS concepts as required, including computer and data structures, input/output systems, and file organization. Survey of programming and database management languages at various levels. This course is for 817 Management students. PREREQUISITES: PS 3005, MN 3105, MN 3211 (concurrently), and CS 0113 (concurrently).

MN 3211 OPERATIONS ANALYSIS FOR MANAGEMENT I (4-0). A survey of the philosophy and methods of operations research. Emphasis is on model building and the application of the models to managerial problems. PREREQUISITES: MA 2306 and PS 3005 or their equivalents.

MN 3212 OPERATIONS ANALYSIS FOR MANAGEMENT II (4-0). A continuation of MN 3211. PREREQUISITE: MN 3211.

MN 3214 OPERATIONS RESEARCH METHODOLOGY (4-0). Review of basic principles of operations research analysis, philosophy, practice, implementation, with emphasis on problem formulation. Survey of problem solving techniques not covered in MN 3211 and MN 3212. Topics include decomposition, networks, Markov Chains, and combat models. Discussion of potential areas for thesis work in Management Science. PREREQUISITES: MN 3211, and MN 3212 concurrently.

MN 3215 SELECTED TOPICS IN MANAGEMENT SCIENCE (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3251 ACCOUNTING THEORY AND STANDARDS (4-0). Study of the basic concepts standards, principles, and practices underlying published financial reports. Specific topics include approaches to the specification of accounting principles, bases of asset valuation, income measurement, and the measurement of corporate equities. Attention is devoted to current generally ac-

cepted accounting principles, to controversial reporting problems, and to prospective new developments. PREREQUISITE: MN 3161.

MN 3371 PROCUREMENT AND CONTRACT ADMINISTRATION (4-0). Study of the elements of the procurement process. Coverage includes the determination of requirements, techniques used in purchasing, the military-industrial complex and its role in providing material and service, the management of on-going programs, and the environment in which the acquisition takes place. Military procurement regulations are analyzed to determine their impact on efficient military logistics systems. PREREQUISITES: MN 3140 or MN 3141.

MN 3372 PHYSICAL DISTRIBUTION AND SUPPLY SYSTEMS (4-0). The quantitative analysis of material logistics systems and supply management problems. Elements of study include inventory theory, data reporting, forecasting, order processing, and system-wide design problems. PREREQUISITE: MN 3211.

MN 3373 TRANSPORTATION MANAGEMENT (4-0). Provides a knowledge of problems and practices encountered in the management of transportation systems. Areas covered include the study of present and future trends in military and commercial transportation systems. PREREQUISITES: MN 3140 or MN 3141.

MN 3374 PRODUCTION MANAGEMENT (4-0). This course examines the production process. Emphasis is distributed among the technical, managerial, and defense aspects of production. Topic coverage ranges from production planning through production control. PREREQUISITES: MN 3105 and MN 3211.

MN 3376 SELECTED TOPICS IN MATERIAL LOGISTICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3645 INVESTIGATIVE METHODS OF ECONOMICS I (4-0). Development and applications of econometric models of particular interest to public sector managers. Topics include demand forecasting, production function estimates and cost estimating. PREREQUISITES: MN 3140 or MN 3141, and MN 3212 (concurrently).

MN 3760 MANPOWER ECONOMICS (4-0). This course contains both theoretical and empirical issues in manpower economics. The theoretical development emphasizes individual employment, job searching, mobility and career decisions. Empirical work presented will include studies on the all-volunteer force, hazardous duty compensation and re-enlistment bonuses. PREREQUISITES: MN 3140 or 3141, or OA 3609.

MN 3770 ECONOMICS OF LABOR AND INDUSTRIAL ORGANIZATION (4-0). Analysis of the structure, conduct and performance of American labor and industry. Topics include the labor movement, industrial organization, regulatory practice, public utilities, the non-profit sector, the military-industrial complex and the use of input-output analysis. Public policy issues will be considered. PREREQUISITE: MN 3140 or MN 3141.

MN 3950 WORKSHOP IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 3960 READINGS IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 3970 SEMINAR IN MANAGEMENT (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

Graduate Courses

MN 4105 MANAGEMENT POLICY (4-0). Study and appraisal of a variety of policies requiring the analysis of problems and the formulation of decisions in both business and governmental enterprises. Use of case material, management games, and other devices as exercises in decision making and the executive action under conditions of uncertainty and change. PREREQUISITE: Open only to students in their final quarter of the Management Masters Program.

MN 4111 HUMAN RESOURCES SEMINAR (4-0). A combination of readings and individual student research reports in the area of human resource goals. Emphasis on empirical analysis. PREREQUISITE: Departmental approval.

MN 4112 PERSONNEL SELECTION AND CLASSIFICATION (4-0). Analysis of human performance within organizations. This course considers the methods available for measuring and predicting the performances of the members of organizations. Methods of measuring differences between people via employment interviewing, testing, and life-history data are discussed. Techniques for studying and recording job behavior are also considered. In addition, the various strategies for personnel decisions are discussed in terms of validation, and selection and placement models. PREREQUISITES: MN 3111.

MN 4113 PERSONNEL TRAINING AND DEVELOPMENT (4-0). Determination of the skills, knowledges and attitudes in which people should be trained. Analysis of who should be trained and the methods currently available for training are discussed. Techniques available for evaluating the efficiency of training are also considered. PREREQUISITES: MN 3111.

MN 4114 PERSONNEL PERFORMANCE EVALUATION (4-0). Current methods of appraising the work performance of individuals in different types of work are reviewed. Problems associated with each method are analyzed. Performance evaluation is examined as a system interfacing with selection, classification, training, advancement, and retention. PREREQUISITES: MN 3111.

MN 4115 PERSONNEL MOTIVATION (4-0). A brief summary of the traditional theories of motivation is given. Several motivation to work theories are discussed along with the research concerning these theories. Current research on the roles of compensation in personnel motivation is considered. PREREQUISITE: MN 3110.

MN 4121 ORGANIZATION THEORY (4-0). Current research and theory to the management function of organizational design. Alternative approaches which consider the properties of mission and technology, personnel, and environmental conditions. PREREQUISITES: MN 3124 or MN 3125.

MN 4123 ORGANIZATION DEVELOPMENT (3-2). A Study of the field of organization development using experimental and laboratory techniques. The course provides initial practice with process consulting skills and survey techniques for the practice or organization development in Navy units. The course covers the tenets of planned organization change to accomplish the organization goals with the best long-range participation of personnel in an effective problem-solving environment. PREREQUISITE: MN 3121.

MN 4126 SELECTED TOPICS IN THE BEHAVIORAL SCIENCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4127 SELECTED TOPICS IN ORGANIZATION AND MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Department approval.

MN 4133 ECONOMICS OF COMPUTERS (4-0). Analytical tools of microeconomics and statistics applied to decision making in

computer management. Economics issues and legal constraints related to computer hardware and software systems are discussed. PREREQUISITES: MN 3140 or MN 3141, PS 3000 and Departmental approval.

MN 4142 INTERNATIONAL TRADE AND DEVELOPMENT POLICY (4-0). Leading issues in trade and development policy. Consideration of the implication of alternative economic systems on national policies. PREREQUISITE: MN 3142.

MN 4145 SYSTEMS ANALYSIS (4-0). This course will concentrate on the analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Systems analysis case studies will be emphasized. PREREQUISITES: MN 3172.

MN 4146 SELECTED TOPICS IN SYSTEMS ANALYSIS AND DEFENSE RESOURCE ALLOCATION (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in systems analysis and resource management and Departmental approval.

MN 4147 INDUSTRIAL RELATIONS (4-0). Development of the institutions and techniques for resolving conflict over wages and conditions of work. Theories of bargaining and arbitration. PREREQUISITE: MN 3101.

MN 4148 SELECTED TOPICS IN PERSONNEL MANAGEMENT AND INDUSTRIAL RELATIONS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in personnel management and industrial relations and Departmental approval.

MN 4151 INTERNAL CONTROL AND AUDITING (4-0). Study of the objectives and procedures of internal control in government and industry. Examination of the independent audit function, including auditing standards and reports. Study of internal auditing, with emphasis on operational audits. Consideration of the principal Federal audit organizations. Specialized topics including sampling techniques for auditing, audits of computer-based systems, and audit problems associated with selected assets and operations. PREREQUISITES: MN 3172, MN 3211.

MN 4152 DECISION MAKING FOR FINANCIAL MANAGEMENT (4-0). The management of the finance function in government and industry. Specific topics include cash and working capital management, long-term financing, determination of optimal capital structure, and valuation of a going concern. PREREQUISITES: MN 3172, MN 3211.

MN 4153 SEMINAR IN ACCOUNTING AND CONTROL (4-0). Research and discussion of current developments and controversies in accounting and financial controls for government and industry. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3172, MN 3211.

MN 4154 SEMINAR IN FINANCIAL MANAGEMENT (4-0). Study of the theories of and applications in the adminstration and allocation of financial resources. PREREQUISITES: MN 3172, MN 3211.

MN 4161 CONTROLLERSHIP (4-0). This course employs the case method of study and seeks to integrate the various disciplines that support the management function, with particular emphasis on financial analysis for decision making. PREREQUISITES: MN 3172, MN 3211.

MN 4162 COST ACCOUNTING (4-0). Review of various definitions of cost and alternative ways of measuring cost. Study of cost accounting systems, methods of allocating costs to cost objects, and the costing of activities, products, and projects. Consideration of the objectives and the substance of Federal cost accounting standards. PREREQUISITE: MN 3161 and knowledge of basic probability and multiple regression analysis.

MN 4165 SELECTED TOPICS IN ACCOUNTING AND FINANCIAL MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in accounting and financial management and Departmental approval.

MN 4172 MARKETING STRATEGY (4-0). Research and study of areas of marketing that are applicable to management strategy. Typical areas to be considered are: sensitivity to the environment; value of analytical tools; behavioral considerations; creativity and innovative approaches; marketing research as a tool; influence of Federal statutes. PREREQUISITES: MN 3211.

MN 4181 APPLICATIONS OF MANAGEMENT INFORMATION SYSTEMS (4-0). Advanced study of management information as it relates to various organizational systems. Students will study actual industrial and/or military organizations in the context of management information systems. The issues of design, implementation, and operation of a management information system will be considered through the use of case studies of industrial and military organizations. This course is primarily for management students. PREREQUISITES: MN 3183.

MN 4185 SELECTED TOPICS IN INFORMATION SYSTEMS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in information systems and Departmental approval.

MN 4191 DECISION ANALYSIS (4-0). A continuation of MN 3212 with particular emphasis on the decision analysis framework for managerial action within DOD. PREREQUISITE: MN 3212.

MN 4192 WORKSHOP IN MANAGEMENT SCIENCE (2-0 to 5-0). This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4193 SELECTED TOPICS IN MANAGEMENT SCIENCE (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4225 LABOR LAW (4/0). Labor Law as it affects management, labor and the public with special emphasis on legal problems confronting military personnel in managerial situations. PREREQUISITE: MN 3101.

MN 4371 PROCUREMENT POLICY (4-0). Case study appraisals of business and government procurement policies. Emphasis is on procurement decision making and policy formulation through the case analysis method. PREREQUISITE: MN 3371.

MN 4373 TRANSPORTATION POLICY (4-0). Advanced study in the management of transportation systems. Emphasis on coordinated transportation management in large-scale systems and its implication for DOD. PREREQUISITE: MN 3373.

MN 4376 SEMINAR IN MATERIAL LOGISTICS (4-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4645 INVESTIGATIVE METHODS OF ECONOMICS II (4-0). Specification of economic systems. Simultaneous equations and identification issues in econometric model construction. Application of econometric methods in analyses of industrial organization and economic planning. PREREQUISITE: MN 3465.

MN 4920 PUBLIC EXPENDITURE ANALYSIS (4-0). A presentation of basic concepts such as public goods, joint production and

externalities which necessitate governmental market intervention. Techniques to analyze the effects and desirability of particular government expenditures are covered and include the theory of second best, cost-benefit analysis, consumer surplus, and social discounting. PREREQUISITES: MN 3140 and MN 3170 or 3172 or OA 3611.

MN 4931 MACROECONOMIC THEORY AND POLICY (4-0). Advanced study of aggregate economic models and their policy implications. Topics considered include econometric macromodels, the relationship of monetary and nonmonetary variables, aggregation, monetary policy, fiscal policy, and the use of DOD expenditures in aggregate economic control. PREREQUISITE: MN 3130.

MN 4941 MICROECONOMIC THEORY AND POLICY (4-0). Advanced study of equilibrium and disequilibrium microeconomic systems. Topics include consumer choice, producer choice, market structure, risk, imperfect competition and regulation, and economic planning models. Policy issues and their implication for national action. PREREQUISITE: MN 3140 or MN 3141 and Departmental approval.

MN 4945 SELECTED TOPICS IN ECONOMICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in economics and Departmental approval.

MN 4950 WORKSHOP IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 4960 READINGS IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 4970 SEMINAR IN MANAGEMENT (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

OPERATIONS ANALYSIS

OA 0001 SEMINAR FOR OPERATIONS RESEARCH/SYSTEMS ANALYSIS STUDENTS (0-2). Guest Lecturers. Review of experience tours. Thesis and research presentations PREREQUISITE: None.

OA 0810 THESIS RESEARCH FOR OPERATIONS RESEARCH/SYSTEMS ANALYSIS STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2600 HISTORY AND NATURE OF OPERATIONS ANALYSIS (2-0). The origins of Operations Analysis in Britain are discussed and the relationship of Operations Research to fundamental and applied research is considered. The application of quantitative analysis and scientific methodology to military operations is introduced by the review of World War II studies of ASW and Air Warfare. PREREQUISITE: None.

OA 2601 INTRODUCTION TO DECISION ANALYSIS (2-0). An introduction to the role of the model in Operations Research, its structure and development, and the interpretation of model results. Emphasis is given to the importance of appropriate criteria and decision variables. A basic structure for decision problems is developed and interpreted for several illustrative cases such as decisions relating to ordnance loads, spare parts levels, and support requirements. PREREQUISITE: OA 2301 (concurrently).

OA 2910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in operations research.

Upper Division or Graduate Courses

OA 3604 LINEAR PROGRAMMING (4-0). Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analyses, parametric linear programming, transportation algorithm and matrix payoff games. Applications to resource allocation, manpower planning, transportation and communications network models, ship scheduling, and elementary strategic games. Introduction to machine computing and MPS. PREREQUISITE: MA 2042.

OA 3605 METHODS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). A first course designed to survey the methodology of operations research and systems analysis. Topics in this sequence include: dynamic programming, PERT and PERT/COST, queueing, reliability, maintenance, replacement, networks, stochastic models, and allocation of search. PREREQUISITE: OA 3604.

OA 3609 INTRODUCTION TO MATHEMATICAL ECONOMICS (4-0). A presentation of the basic economic concepts involved in the decision process of individuals and other entities faced with scarcity of resources. The goal is to provide sufficient background to allow accurate incorporation of economic incentives in descriptive and optimization models constructed in the process of doing systems analyses. Topics covered include opportunity cost, incremental analysis and its relation to decision rules, linear and nonlinear production processes, partial equilibrium analysis, ordinal and cardinal utility and welfare criteria. PREREQUISITES: MA 2110, MA 2042.

OA 3610 UTILITY THEORY AND RESOURCE ALLOCATION (4-0). Extension of the concepts discussed in OA 3609 to the analysis of decisions involving the welfare of groups of individuals. Covered are externalities, public goods, joint production, nonmarket decision making through shadow pricing. Also covered is an introduction to the macroeconomic structure within which the micro decisions previously covered are made. Included is income determination and sector analysis with policy discussions and evaluation. PREREQUISITE: OA 3609.

OA 3611 SYSTEMS ANALYSIS I (4-0). Principles of systems analysis and their relationship to the planning, programming, and budgeting system (PPBS), and the traditional OR models. Analysis of effectiveness measures and models. Cost estimating and analysis. Overall structure of cost-effectiveness and decision criteria. Risk and uncertainty problems. PREREQUISITES: OA 3604, OA 3610, OA 3303.

OA 3612 SYSTEMS ANALYSIS II (4-0). This course is to provide an integrated view of the nature of operations analysis. Projects are extensively used to permit the student a wide ranging final internship in the practice of operations research and systems analysis. PREREQUISITE: Open only to students in their final quarter of the Operations Research/Systems Analysis Master's Program.

OA 3620 INVENTORY I (4-0). A study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite and finite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic "order up to R" model. Single period stochastic models. PREREQUISITES: MA 2110, OA 3302.

OA 3653 SYSTEM SIMULATION (4-0). Computer Simulation as a problem solving technique. Subject areas covered include:

Monte Carlo methodology, simulation programming in FORTRAN, GPSS and other available simulation languages; and design of simulation experiments and analysis of results. PREREQUISITES: CS 0110 or equivalent, OA 3302.

OA 3654 WAR GAMING (3-2). Consideration of the problems inherent in the construction and use of manual and computer war games. Problems in the analysis of results of such games. PREREQUISITES: OA 3653, OA 3302.

OA 3656 OPERATIONS RESEARCH PROBLEMS IN SPECIAL WARFARE (4-0). The applicability of operations research to unconventional warfare and counterinsurgency. Normative and descriptive models. Consideration of special problems with emphasis on problem formulation. PREREQUISITES: OA 3604, OA 3303.

OA 3657 HUMAN FACTORS IN SYSTEMS DESIGN I (4-0). The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. PREREQUISITES: OA 3604, OA 3303.

OA 3658 HUMAN FACTORS IN SYSTEMS DESIGN II (3-0). A continuation of OA 3657. Man-machine interface and man's motor and sensory capacities. PREREQUISITES: OA 3657 or Departmental approval.

OA 3660 ANALYSIS OF OPERATIONAL DATA (3-1). Analysis of real world operational data. The processing and interpretation of incomplete operational data. Problems will be chosen from current military problems. PREREQUISITES: OA 3303, OA 3653.

OA 3664 THEORY OF PATTERN RECOGNITION (3-0). Survey of principles governing the design of pattern recognition and detection devices of both the adaptive and nonadaptive types. Basic visual and auditory anatomy, along with the concepts and theories applicable to solving man's visual behavior problems in his role as a photo interpreter, radar operator, sonar operator or similar vigilance and tracking tasks. PREREQUISITE: OA 3303 or equivalent.

OA 3704 STOCHASTIC MODELS I (4-0). The primary goal of the course is to gain the theory necessary for stochastic modeling with Markov models. Particular topics include the homogenous and inhomogenous Poisson Process, filtered Poisson Process, compound Poisson Process, stationary Markov Chains, and the algebraic properties of finite Markov Chains. The theory is augmented by examination and discussion of actual applications such as manpower management. PREREQUISITE: Basic probability with calculus as in OA 3302.

OA 3900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

OA 3910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

Graduate Courses

OA 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (3-1). Attribute and variables sampling plans. MIL. STD. sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: OA 3303.

OA 4323 DECISION THEORY (3-0). Basic concepts. Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluations trials. PREREQUISITE: OA 3303.

OA 4613 THEORY OF SYSTEMS ANALYSIS (4-0). Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing decentralization of the decision-making problem. PREREQUISITES: OA 3611, OA 4631 (concurrently).

OA 4614 METHODS AND PRACTICE OF SYSTEMS ANALYSIS (4-0). Advanced study in the methods and practice of systems analysis with emphasis on cost analysis; cost models and methods for total program structures and single projects; relationship of effectiveness models and measures to cost analyses; public capital budgeting of interrelated projects; detailed examples from current federal practices. PREREQUISITE: OA 3611.

OA 4615 ECONOMETRICS (4-0). An introduction to the construction of testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITES: OA 3303, OA 3610.

OA 4616 DEFENSE EXPENDITURE AND POLICY ANALYSIS (4-0). A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them. PREREQUISITE: OA 3611.

OA 4621 INVENTORY II (4-0). A study of stochastic inventory models. Single period models with time dependent costs, constrained multiple item single period models, deterministic and stochastic dynamic inventory models, the (r,R) periodic review model, the Q = 1 continuous review model, demand forecasting. PREREQUISITES: OA 3704, OA 3620.

OA 4622 SEMINAR IN SUPPLY SYSTEMS (4-0). A survey of supply systems, not only from an inventory point of view, but also as a critical area in logistics. Topics for discussion will be selected from the current literature and will be chosen according to students interests. Periodically, experts in the supply field will provide guest lectures on current research areas. PREREQUISITES: OA 4621, OA 3704, or Departmental approval.

OA 4631 NONLINEAR AND DYNAMIC PROGRAMMING (4-0). Introduction to modern optimization techniques and multistate decision processes. Kuhn-Tucker necessary and sufficient conditions for optimality, quadratic and separable programming, basic gradient search algorithms. SUMT penalty function method, dynamic programming. Applications to weapons assignment, force structuring, parameter estimation for nonlinear or constrained regression, personnel assignment and resource allocation. PREREQUISITE: OA 3604.

OA 4632 MATHEMATICAL PROGRAMMING (4-0). Advanced topics in linear programming. Large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, probabilistic programming, formulation and solution procedures for problems in integer variables. Applications to the cutting stock problem, capital budgeting, large scale distribution systems, weapon systems allocations and others. PREREQUISITE: OA 3604.

OA 4633 NETWORKS FLOWS AND GRAPHS (4-0). Survey of solution techniques for problems which can be related to problems involving flows in networks. Elements of graph theory, max-flow

min-cut theorem, shortest route problems, minimal cost flows, out-of-kilter algorithm, CPM, PERT/Cost, and PERT/Time. PREREQUISITE: OA 3604.

OA 4634 GAMES OF STRATEGY (4-0). Games as mathematical models of conflict situations. Fundamental concepts: objective and subjective basis. The canonical, dynamic, and characteristic function forms. Zero-sum, n-person noncooperative and multistage games. Coalitions and cooperative games with and without side payments. Postulates of rational behavior, dominance, and stability. Valuation and bargaining models. PREREQUISITE: OA 3610.

OA 4635 NONLINEAR PROGRAMMING (4-0). Continuation of OA 4631. Advanced topics in nonlinear programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods and examination of recent literature in nonlinear programming. PREREQUISITE: OA 4631.

OA 4636 DYNAMIC PROGRAMMING (4-0). A continuation of OA 4631. Basic theory of dynamic programming with numerous optimization and resource allocation applications in the areas of reliability design, target selection, inventory theory, project selection, and others. PREREQUISITE: OA 4631.

OA 4638 VARIATIONAL METHODS OF OPTIMIZATION (4-0). Continuous time decision processes. Optimization techniques include classical calculus of variations, optimal control theory and differential games. Applications will be made to inventory theory, tactical allocation problems, search, pursuit, evasion, and surveillance. PREREQUISITE: OA 4631 or OA 4654, or equivalent.

OA 4639 CONTROL IN ECONOMICS (4-0). After introducing the theoretical tools, this course will concentrate on studying applications of optimal control theory to economic problems. Included will be studies of economic growth, production with learning, inventory control, and biological problems. PREREQUISITES: OA 3610, OA 4631.

OA 4642 ADVANCED TOPICS IN WAR GAMING AND SIMULATION (3-2). A greater-depth coverage of material introduced in OA 3653 and OA 3654. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and instructor. This course is particularly appropriate for those doing theses in this area. PREREQUISITE: OA 3654 and Departmental approval.

OA 4651 SEARCH THEORY AND DETECTION (4-0). Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITE: OA 3303 or equivalent.

OA 4652 OPERATIONS RESEARCH PROBLEMS IN NAVAL WARFARE (3-0). Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communication, and ECM problems. PREREQUISITE: OA 4651.

OA 4653 OPERATIONAL TEST AND EVALUATION (3-2). This course relates the theory and techniques of operations research to the problems associated with operational test and evaluation. Specific examples of exercise design, reconstruction, and analysis are examined. PREREQUISITES: OA 3660, OA 4651 or OA 4654.

OA 4654 MATHEMATICAL MODELS OF COMBAT (4-0). Survey of mathematical models of combat processes. Models of interest will include target acquisition, tactical allocation models of two-sided dynamic situations, coverage models, theory of duels, Lanchester theory of combat, and stochastic combat processes. Introduction to the optimization of combat dynamics using dynamic programming, optimal control theory, and differential games. PREREQUISITE: OA 3704 or equivalent.

OA 4655 OPTIMIZATION OF COMBAT DYNAMICS (4-0). Study of the optimization of combat dynamics using dynamic programming and optimal control theory combined with the Lanchester theory of combat. Allocation of effort in search theory, distribution of gunfire, selection of aim point distribution. Advanced topics in stochastic combat processes (surveillance of region, Lanchester attrition-rate distribution) and Lanchester theories (range/time dependent attrition rates). Strategy in a missile war: targets and rates of fire. PREREQUISITE: OA 4654.

OA 4662 RELIABILITY AND WEAPONS SYSTEM EFFECTIVENESS MEASUREMENT (4-0). Component and System reliability functions and their point and interval estimates under various sampling plans. Review of selected MILSTD reliability of documents and the WSEIAC reports. Reliability and System effectiveness measurement and analysis of the Fleet Ballistic Missile Weapon System and other selected Weapons systems. Measurement indices for Weapons System Effectiveness. PREREQUISITE: OA 4705 (may be taken concurrently) or equivalent.

OA 4680 HUMAN PERFORMANCE EVALUATION (4-0). Experimental considerations, strategy, and techniques in evaluation of human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variables affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3657.

OA 4685 SKILLED OPERATOR PERFORMANCE (3-2). First part of the course is devoted to an examination of the theoretical foundations of skilled performance. The second half of the course is devoted to the study of the acquisition, development and prediction of skilled operator performance in the operational setting. PREREQUISITE: OA 3657.

OA 4695 OPERATIONS RESEARCH IN MAN-MACHINE SYSTEMS (4-0). The course emphasizes the application of operations research techniques to man-machine system design and evaluation problems. Specific methodologies will be incorporated from mathematical programming, stochastic processes, decision theory, and other related areas. Quantitative methods for performance will be treated using such concepts as reliability, information theory, and signal detection theory. A portion of the course will be devoted to summarizing approaches to real world problems incorporating current methods from the literature. PREREQUISITES: OA 3657, OA 3604, OA 3704, and OA 4705 (may be taken concurrently).

OA 4705 STOCHASTIC MODELS II (3-2). The primary objective of this course is to gain experience in stochastic modeling by performance of a suitable project. Projects usually entail data collection and analysis, formulation of model assumptions and application of the model to answer specific questions or help explain a particular phenomenon. Past projects include military manpower modelling, studies of military health care facilities, studies in local police departments, and many other topics. The theory as developed in OA 3704 is extended to the study of non-Markovian systems. PREREQUISITE: OA 3704.

OA 4706 STOCHASTIC MODELS III (4-0). The course will cover selected topics in queueing theory relevant to applications. Included will be deterministic queues, priority queueing systems

with applications such as cm computer time sharing, inequalities and approximations for general single served queues, multichannel and tandom queue approximations, and heavy traffic queues with applications of the diffusion process. PREREQUISITE: OA 4705.

OA 4900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis.

OA 4910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research and Departmental approval.

OA 4930 READINGS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

OTHER SERVICE COURSES

Lower Division Course

OS 1500 PERSONAL AFFAIRS (2-0). Personal estate planning including: government benefits, insurance, budgeting, real estate, securities, wills and trusts. PREREQUISITE: None.

Upper Division Courses

OS 2201 ELEMENTS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). An introductory course. Topics covered include nature, origin, and contemporary status of operations analysis; problem formulation. PREREQUISITE: PS 2501 or equivalent.

OS 2202 DESCRIPTIVE STATISTICS AND OPERATIONS RESEARCH MODELS (2-0). Elementary OR models applicable to ASW. Descriptive statistical procedures for organizing ASW data. Elementary ASW probability models. ASW detection and attack models. This course was designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: None.

Upper Division or Graduate Courses

OS 3062 INTELLIGENCE DATA ANALYSIS (4-2). A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of intelligence data. Topics include sampling methods, content analysis, data handling and processing overview, scaling techniques, and parametric and nonparametric tests with emphasis on application. The student will be exposed to a wide spectrum of data relating to international problems, with particular emphasis on international commerce and trade, and national maritime capabilities. PREREQUISITES: PS 3000 or equivalent, CS 2100. May also be offered as GV 3062.

OS 3201 FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). An introduction to quality assurance elements including design reliability assessment, production assessment testing, environmental testing, system reliability demonstration. Introduction to hardware performance measures. Introduction to cost effectiveness analysis. Elements of probability and statistics developed as needed. PREREQUISITE: Differential and integral calculus.

OS 3203 METHODS OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). Methodology of operations analysis/systems analysis. Statitical estimation, and hypothesis testing. Life testing plans, point and interval estimates and reliability parameters. Elements and systems analysis pertaining to redundancy, maintainability, and spares. The role of systems analysis in solving military problems. PREREQUISITE: OS 3201 or equivalent.

OS 3203 SURVEY OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). A survey of the military applications of operations analysis/systems analysis techniques of particular interest to the student. The applications usually covered are selected from decision, waiting lines, resource allocation, replacement, cost-effectiveness, inventory theory, and search models. The techniques needed for these applications are developed as required and usually include topics in linear programming (including the simplex method), probability theory, nonlinear programming, statistics (including Bayesian and classical), dynamic programming and simulation. PREREQUISITE: PS 3411 or equivalent.

OS 3204 DEFENSE RESOURCE ANALYSIS (4-0). The aim of this course is to present the nature, the aims, and limitations of analysis as it exists today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the field of interest of the class will be discussed. PREREQUISITE: None.

OS 3205 OPERATIONS RESEARCH FOR COMPUTER SCIENTISTS (4-0). An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, PS 3326, and CS 0110.

OS 3206 OPERATIONS RESEARCH FOR MECHANICAL ENGINEERS (4-0). A survey of operations research techniques of particular interest to the mechanical engineer. Linear programming, sequencing and scheduling, integer programming, decision theory, geometric programming, networks, simulation. Probability concepts developed as needed. PREREQUISITES: MA 1100 and MA 2045 or equivalent.

OS 3207 OPERATIONAL ANALYSIS FOR NAVAL INTELLIGENCE (4-0). An introduction to the methodology and techniques of operations research, with special emphasis on specific areas relevant to naval intelligence such as decision-making under risk and uncertainty, forecasting, search, detection, resource allocation, and queues. PREREQUISITE: PS 3000 or equivalent.

OS 3501 BEHAVIORAL SCIENCE IN MANAGEMENT (4-0). Survey of selected behavioral science concepts and research findings with emphasis upon their managerial use. Topics included are motivation, interpersonal and group processes, leadership and the interrelations of various management practices with human behavior in organizations. Enrollment restricted to non-management students. PREREQUISITE: Graduate standing.

OS 3510 ORGANIZATIONAL BEHAVIOR AND NAVAL INTELLIGENCE (4-0). An examination of the different approaches to the study of public management and their relevance to the administration of naval intelligence. After a brief introduction to the organization theory, measures of organizational effectiveness and group decision making, a number of American intelligence organizations are analyzed. PREREQUISITE: GV 3061.

OS 3651 SEARCH, DETECTION, AND LOCALIZATION MODELS (4-0). An introduction to the decision problems associated with Navy detection systems. The relation of detection models to search and localization models, measures of effectiveness of search/detection systems, and the optimum allocation of search effort are discussed. The last week of the course requires participation in an ASW related group project. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: PS 3411 and SECRET clearance.

OS 3652 INTRODUCTION TO COMBAT MODELS AND WEAPONS EFFECTIVENESS (4-1). This course deals with the application of more or less abstract models to military problems. Topics include Lanchester's Theory, Game Theory, Reliability Theory, Systems Effectiveness, and War Gaming. The last week of the course requires participation in an ASW related group project. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITES: PS 3411 and MA 2129 and SECRET clearance.

OS 3659 HUMAN FACTORS ENGINEERING FOR STUDENTS NOT IN OPERATIONS ANALYSIS (3-0). An introduction to human factors engineering for students in other fields such as engineering. Designed to give the student an appreciation of man's capacities and limitations and how these can effect the optimum design of the man-machine system. Emphasis on integration of human factors into the system development cycle considering such topics as manpower/personnel costs, control and display design, human energy expenditure, physiological costs, and evaluation systems. PREREQUISITE: A previous course in probability and statistics.

OS 3661 DECISION ANALYSIS AND DATA ANALYSIS (4-0). This course relates the theory and techniques of data analysis and operations research to ASW analysis problems. It is primarily for students in the Operational Systems Technology (ASW) program. Emphasis is placed upon the analysis of data in the ASW environment. PREREQUISITES: OS 2202, PS 3411 or equivalent.

OS 3665 HUMAN VIGILANCE PERFORMANCE (3-1). Course involves an examination of man's attentiveness and capability in the detection of changes in stimulus events over prolonged periods of observation. Topics to be covered include theories of vigilance; task, signal, subject and environmental influences on performance; physiological and psychological responses and vigilance performance measurement. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: OS 3661.

OS 3941 ENGINEERING ECONOMICS (4-0). An introduction to the basic concepts of microeconomics necessary for decision making; alternative market models; theories of production, with particular attention to technological considerations, production and cost functions; and supply curves. The analysis of investment decision problems. PREREQUISITE: None.

Graduate Courses

OS 4063 FORECASTING, THREAT ANALYSIS AND NET ASSESSMENT (4-0). A study of the intuitive, exploratory and normative forecasting methods, including brainstorming, Delphi, time series, scenario writing, uncertainty, cost benefit, input-output approaches. Conflict modelling; introduction of models of armament races and international conflict. Implications of such models for analyzing threats; search procedures for generating alternatives. Net asessment of such alternatives. PREREQUISITES: OS 3207, GV/OS 3062, GV 3420. May also be offered as GV 4063.

OS 4207 SPECIAL TOPICS IN THE ANALYSIS OF INTELLIGENCE PROBLEMS (4-0). An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. Applications of cost/benefit and input-output modelling to intelligence decision problems such as collection management, collection system design, data handling and manipulation. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: GV/OS 3062, OS 3207, GV/OS 4063. May also be offered as GV 4207.

OS 4643 ASW WAR GAMING (3-0). The development and use of war games for the analysis of ASW problems. The form and qualities of the various kinds of war games are discussed and a manual-machine ASW Campaign model is developed and used. PREREQUISITE: OS 3661 or equivalent and SECRET clearance.

OS 4665 SYSTEMS PSYCHOLOGY (4-0). Course will be devoted to an examination of man's role and effectiveness as a system component. The major emphasis of the course is placed on the human aspects of the system. The course will examine human behavior in a systems context. Topics to be covered include motivation, perception and communication with emphasis being placed on the personnel sub-system and its interacting elements. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITE: OS 3665.

SYSTEMS ACQUISITION MANAGEMENT

SM 0001 SEMINAR FOR SYSTEMS ACQUISITION MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

SM 0810 THESIS RESEARCH FOR SYSTEMS ACQUISITION MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division or Graduate Courses

SM 3301 INTRODUCTION TO SYSTEMS ACQUISITION (4-0). This course provides students with an overview of the Systems Acquisition process, its underlying philosophies and concepts, its application in the Department of Defense and the Navy, and establishes the foundations for other courses in the curriculum. Topics covered include the evolution of systems acquisition management, the systems approach, the system life cycle and defense system acquisition cycle, user-producer acquisition management disciplines and activities. PREREQUISITE: None.

SM 3302 FUNDAMENTALS OF PROJECT MANAGEMENT (4-0). Study of the principles of management as a body of knowledge related to practice. Discusses the functions of management planning, organizing, staffing, directing, and controlling—as they apply within industry and government. Specific application of these principles and functions to project management are investigated. PREREQUISITE: None.

SM 3306 SYSTEMS EFFECTIVENESS CONCEPTS AND METHODS (4-0). An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness considerations. PREREQUISITES: OS 3202, OS 3203 (concurrently).

Graduate Courses

SM 4301 SYSTEMS ENGINEERING MANAGEMENT (4-0). This course covers technical management as applied to the Systems Acquisition process. It emphasizes the life cycle integration of the various systems engineering disciplines. Topics include systems engineering, the system life cycle and system design process, systems engineering disciplines and their integration, systems engineering management during concept formulation, system definition, full scale development, production and deployment. PREREQUISITES: SM 3301, SM 3302, OA 4662.

SM 4302 PUBLIC EXPENDITURE, POLICY AND ANALYSIS (4-0). The process of national decision-making particularly as reflected in the defense budgeting process. Models of budget decision making, including decentralization. Application of social choice concepts. Applications from the defense budgeting process. PREREQUISITES: MN 3161, MN 4145.

SM 4303 PROCUREMENT PLANNING & NEGOTIATION (4-0). Study of the procurement planning and negotiation phases of the procurement cycle, including the determination of need, basic contract law, methods of procurement, fundamentals of the Armed Services Procurement Regulations and current procurement management techniques. PREREQUISITES: SM 3301, SM 4301 (concurrently).

SM 4304 CONTRACT ADMINISTRATION (4-0). Study of defense procurement contract administration, managing contract progress, change control, cost control, sub-contracting regulations and administration, product acceptance and contract termination. PREREQUISITE: SM 4303.

SM 4305 LOGISTIC SUPPORT (4-0). This course defines and describes the major fields of logistic support and introduces various models of logistical areas. These areas of support include: personnel, consumables, facilities, material transportation and maintenance. The field of integrated logistics support is introduced along with trade-offs between types of support in optimizing support systems. Data bases and techniques for determination of support requirements are treated briefly. PREREQUISITE: SM 4301.

HUMAN GOALS

Upper Division Course

HG 2001 SOCIAL SYSTEM DYNAMICS (2-4). Studies and experiential learning laboratory for the Navy's Human Goals Program. This course meets the Navy's race relations education requirement for students and covers the areas of drug and alcohol abuse, intercultural relations and organization development. Personal awareness and perception of current social problems in the Navy are examined through a variety of presentations and learning techniques. This course is designed primarily for undergraduate students. PREREQUISITES: HI 2203 and PY 2050. Graded on Pass/Fail basis only.

Upper Division or Graduate Courses

HG 3001 HUMAN RESOURCE MANAGEMENT (2-2). Studies and experiential learning laboratory for the Navy's Human Goals Program meeting the Navy requirements for race relations education for students without previous studies in the behavioral sciences. The course emphasizes the need and processes for dealing with current social problems in the areas of race, drugs, intercultural relations and organization development. Awareness and perceptions in these four areas are examined. Enrollment restricted to non-management students. PREREQUISITE: Graduate standing. Graded on Pass/Fail basis only.

HG 3002 HUMAN RESOURCE DEVELOPMENT (2-4). Studies and experiential learning laboratory for the Navy's Human Goals Program. The course emphasizes the importance of dealing with persistent social problems in the military, provides knowledge in the four topical areas of race, drugs, intercultural relations and organization development. Awareness of personal attitudes and processes for working in these areas are examined. Enrollment restricted to management students. PREREQUISITES: Behavioral Sciences and Management Theory. Graded on Pass/Fail basis only.

PROBABILITY AND STATISTICS

Upper Division Course

OA 2301 PROBABILITY (4-0). Probability axioms and event probability. Random variables and their probability distributions. Moment generating functions, moments and other distribution characteristics. Distribution families characterized by parameters. Functions of a random variable. Jointly distributed random variables, independence and conditional distributions; correlation. PREREQUISITE: None.

Upper Division or Graduate Courses

OA 3302 PROBABILITY AND STATISTICS (4-1). Random samples. Derived distributions of functions of several random variables. Order statistics, the t and F distributions. Limiting distributions, the central limit theoren and approximations. Bivariate normal distribution; extension to the multivariate normal family. Point estimation; unbiasedness, maximum likelihood and Bayes. Interval estimation; confidence intervals and Bayesian intervals. PREREQUISITE: OA 2301.

OA 3303 STATISTICS (4-1). Confidence interval estimation and hypothesis testing. Regression and correlation analysis. Elements of the analysis of variance. Nonparametric inference. Applications to reliability, quality assurance, and operations analysis problems. PREREQUISITE: OA 3302.

Graduate Courses

OA 4306 APPLIED STATISTICS (4-0). Multivariate analysis with applications. Multiple comparisons. Bayesian and classical classification models. Outliers. Use of digital computer in multivariate problems. PREREQUISITE: OA 3303.

OA 4321 DESIGN OF EXPERIMENTS (3-1). Theory of the general linear hypotheses. Analysis of variance. Planning of experiments. Randomized block and Latin squares. Simple factorial experiments. PREREQUISITE: OA 3303.

OA 4431 ADVANCED PROBABILITY (3-0). Convergence almost surely, in probability and in quadratic mean. Distribution function and characteristic functions. Infinitely divisible laws. Strong and weak laws of large numbers. Classical central limit problems moder central limit problems. PREREQUISITE: MA 3606, MA 3172, and Departmental approval.

OA 4432 STOCHASTIC PROCESSES I (4-0). The Kolmogorov Theorem. Analytic properties of sample functions. Continuity and differentiability in quadratic mean. Stochastic integrals. Stationary processes. PREREQUISITE: OA 4431.

OA 4433 STOCHASTIC PROCESSES II (4-0). Continuation of OA 4432. Stationary and non-stationary normal processes. Diffusion and random walks. Crossing problems. Martingale, limit theorems and the invariance principle. PREREQUISITE: OA 4432.

OA 4440 TIME SERIES ANALYSIS (4-0). Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral windows. Ergotic properties. Problems of inference in time series analysis. Introduction to the analysis of multivariate processes. Course should be taken concurrently with OA 4432.

OA 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: OA 3303 or Departmental approval. Graded on Pass/Fail basis only.

DEPARTMENT OF PHYSICS AND CHEMISTRY

OTTO HEINZ, Professor of Physics; Chairman (1962)*; B.A. Univ. of California at Berkeley, 1948; Ph.D., 1954.

ROBERT LOUIS ARMSTEAD, Associate Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1964.

FRED RAMON BUSKIRK, Associate Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

ALFRED WILLIAM MADISON COOPER, Associate Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's University of Belfast, 1961.

JOHN NIESSINK COOPER, Professor of Physics (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

ALAN BERCHARD COPPENS, Associate Professor of Physics (1964); B.Eng.Phys., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., 1965.

EUGENE CASSON CRITTENDEN, JR., Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

WILLIAM PEYTON CUNNINGHAM, Distinguished Professor of Physics and Operations Research (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

HARVEY ARNOLD DAHL, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

EDGAR BRANDON DALLY, Associate Professor of Physics (1970); B.A., Miami Univ., 1953; M.S., 1955; Ph.D., Stanford Univ., 1961.

JOHN NORVELL DYER, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

HARRY ELIAS HANDLER, Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

DON EDWARD HARRISON, JR., Professor of Physics (1961); B.S., College of William and Mary 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

SYDNEY HOBART KALMBACH, Professor of Physics (1947); B.S., Marquette Univ., 1934; M.S., 1937.

RAYMOND LEROY KELLY, Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

XAVIER KUNITERU MARUYAMA, Lieutenant, U. S. Navy; Assistant Professor of Physics (1971); B.S., Univ. of Notre Dame, 1966; Ph.D., Massachusetts Institute of Technology, 1971.

HERMAN MEDWIN, Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S., Univ. of California at Los Angeles, 1948; Ph.D., 1953.

EDMUND ALEXANDER MILNE, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

JOHN ROBERT NEIGHBOURS, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

LEONARD OLIVER OLSEN, Professor of Physics (1960); B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

WILLIAM REESE, Professor of Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

RICHARD ALAN REINHARDT, Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

GEORGE WAYNE RODEBACK, Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

CHARLES FREDERICK ROWELL, Associate Professor of Chemistry (1962); B.S., Syracuse Univ., 1956; M.S., Iowa State Univ., 1959; Ph.D., Oregon State Univ., 1964.

JAMES VINCENT SANDERS, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

GORDON EVERETT SCHACHER, Associate Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

JOHN WILFRED SCHULTZ, Associate Professor of Chemistry (1958); B.S., Oregon State College, 1953; Ph.D., Brown Univ., 1957.

FRED RICHARD SCHWIRZKE, Associate Professor of Physics (1967); B.S., Univ. of Rostock, 1950; M.S., Univ. of Karlsruhe, 1953; Ph.D., 1959.

JAMES EDWARD SINCLAIR, Professor of Chemical Engineering (1946); B.S., Ch. Eng., Johns Hopkins Univ., 1945; M.S., Naval Postgraduate School, 1956.

WILLIAM MARSHALL TOLLES, Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

KARLHEINZ EDGAR WOEHLER, Professor of Physics (1962); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

WILLIAM BARDWELL ZELENY, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S., Syracuse Univ., 1958; Ph.D., 1960.

EMERITUS FACULTY

NEWTON WEBER BUERGER, Professor Emeritus (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1939.

AUSTIN ROGERS FREY, Distinguished Professor Emeritus (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

WILLIAM WISNER HAWES, Professor Emeritus (1952); B.S., Ch. Eng., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

GILBERT FORD KINNEY, Distinguished Professor Emeritus (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

LAWRENCE EDWARD KINSLER, Distinguished Professor Emeritus (1946); B.S., California Institute of Technology, 1931; Ph.D., 1934.

GEORGE DANIEL MARSHALL, JR., Professor Emeritus (1946); B.S., Yale Univ., 1930; M.S., 1932.

GEORGE HAROLD MCFARLIN, Professor Emeritus (1948); B.A., Indiana Univ., 1925; M.A., 1926.

MELVIN FERGUSON REYNOLDS, Professor Emeritus (1946); B.S. Franklin and Marshall College, 1932; M.S. New York Univ., 1935; Ph.D., 1937.

JOHN DEWITT RIGGIN, Professor Emeritus (1946), B.S. Univ. of Mississippi, 1934; M.S., 1936.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEGREE REQUIREMENTS

The Department of Physics and Chemistry offers the MS and BS degrees in Physics, in Chemistry and in Applied Science. In addition, the Ph.D. is offered by the Department. Upon approval by the Department, courses taken at other institutions may be applied towards satisfying degree requirements.

BACHELOR OF SCIENCE IN PHYSICS

1. A major in physics must include a minimum of 45 quarter hours in physics (including core courses and electives), a minimum of 24 quarter hours in mathematics, and the equivalent of a course in general chemistry. A minimum of 17 quarter hours of elective credits must be chosen from the natural sciences or engineering, other than physics or mathematics. Seventy-two quarter hours must be clearly of upper division level.

2. The following subjects constitute a typical core: (subjects marked with an asterisk must include a laboratory).

Subject	*Approximate Quarter Hours*
General Physics*	13
Analytical Mechanics	7
Electricity and Magnetism	6
Thermodynamics	3
Modern Physics*	10
	39

The mathematics courses shall include differential equations and vector analysis.

3. The student must maintain grade point averages of at least 2.2 in both physics and mathematics.

4. Each student's program must be approved by the Chairman of the Department of Physics and Chemistry before the student embarks on the upper-division portion of the major requirements.

MASTER OF SCIENCE IN PHYSICS

1. A candidate for the degree Master of Science in Physics must complete satisfactorily a program of study which includes a minimum of 30 quarter hours of physics courses (not including thesis) distributed among courses at the graduate level; of this 30 hours at least 15 hours must be at the 4000 level. Upon approval of the Chairman of the Physics and Chemistry Department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses. In addition, all students must present an acceptable thesis.

2. The following specific course requirements must be successfully completed for a student to earn the degree of Master of Science in Physics:

a. Thermodynamics and Statistical Mechanics—the student must take a two-quarter sequence or present equivalent preparation in this area.
b. A course in Advanced Mechanics or Quantum Mechanics.
c. A course in Electromagnetism at the 4000 level.
d. An advanced course in Modern Physics.
e. Specialization, to include at least two advanced courses in an area of specialization.

3. Programs leading to the Master of Science degree in Physics must be approved by the Chairman of the Department of Physics and Chemistry.

MASTER OF SCIENCE IN APPLIED SCIENCE

A candidate for the degree Master of Science in Applied Science must complete satisfactorily a program of study which includes 20 quarter hours of courses in physics and/or chemistry at the graduate level including work at the 4000 level; a departmentally approved sequence containing a minimum of 12 hours at the graduate level which emphasizes a specific application of science and which is taken outside the Department of Physics and Chemistry; of the above 32 quarter hours of work at the graduate level at least 12 must be in 4000 level courses. The candidate must present an acceptable thesis on a topic given prior approval by the Department of Physics and Chemistry. Final approval of all programs leading to the Master of Science in Applied Science shall be obtained from the Chairman of the Department of Physics and Chemistry.

BACHELOR OF SCIENCE IN CHEMISTRY

1. A major in chemistry should include a minimum of 44 quarter hours of chemistry including required courses and electives, 17 quarter hours of physics (including general and modern physics), 18 quarter hours of mathematics (including differential equations), and 12 quarter hours of elective upper division courses in engineering, mathematics, or science.

2. The following specific requirements must be met. Courses marked with an asterisk must include laboratory.

Subject	Approximate Quarter Hours
General*, inorganic*, analytical* chemistry, and instrumental analysis*	14
Organic chemistry*	9
Physical chemistry* and Thermodynamics	12
Chemistry electives, upper division	9
	44

MASTER OF SCIENCE IN CHEMISTRY

1. To obtain a degree, Master of Science in Chemistry, the student must have completed work equivalent to the Bachelor of Science requirements of this department, with the exception of the electives.

2. In addition the student must successfully complete the following with a grade point average of 3.0 in all chemistry courses:

a. One graduate course in each of the following areas: Statistical Mechanics, Inorganic Chemistry, Physical-Organic Chemistry and Quantum Chemistry. Minimum total quarter hours—13.
b. Two or more additional courses at the 4000 level in chemistry. These courses must have a total of not less than six quarter hours of lecture and must be approved by the Department. Minimum total quarter hours—6.
c. Sufficient supporting courses in science, mathematics and engineering to meet school requirements.

3. Must present an acceptable thesis.

DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Department in several areas of specialization which currently include Acoustics, Atomic Physics, Nuclear Physics, Plasma Physics, Solid State Physics and Theoretical Physics.

Requirements for the degree may be grouped into 3 catagories: courses, thesis research, and examinations in major and minor fields and languages.

The required examinations are described elsewhere in this catalogue in the section Requirements for the Doctor's Degree. In addition to the school requirements the department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Advanced Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. (PH 4171, 4371, 4971, 4972, 4973, 4571, 4572.) Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

PHYSICS AND CHEMISTRY LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in nuclear physics, solid state physics, electro-optics, plasma physics, spectroscopy, and acoustics.

A 100-MeV electron linear accelerator with 5-microamp beam current is used in nuclear physics research as well as radiation effects studies. A 2-MeV Van de Graaff accelerator is also available for nuclear and atomic physics work.

In low temperature and solid state physics the equipment includes nitrogen liquifiers, a Collins helium liquefier, He_3 refrigeration equipment to reach temperatures below 1°K, a 12-inch uniform field electromagnet, microwave instrumentation for spin resonance, maser studies, and materials studies, and high-frequency pulse acoustic equipment for phonon studies.

The electro-optics laboratory uses imaging and detecting systems from the far infrared to the visible range including instrumentation for sea-going experiments in optical propagation. The laser laboratory contains a giant pulse laser and associated detection equipment for the visible spectrum as well as a high power laser in the IR region.

The plasma physics laboratory includes a plasma system, diagnostic equipment for studies of plasma dynamics, and a steady state plasma source with magnetic fields to 10,000 gauss.

The spectroscopy equipment includes a large grating spectrograph, a large prism spectrograph, and an infrared spectrophotometer. The spectroscopic data center contains a comprehensive compilation of the known energy levels and atomic spectral lines in the vacuum ultraviolet range.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test and wave tanks, and instrumentation for investigation in underwater sound comprise the underwater acoustics laboratory.

The chemical laboratories provide facilities for undergraduate and graduate study and research in chemistry. Supporting these activities are: a molecular spectroscopy laboratory, including infrared, ultraviolet, and magnetic resonance (ESR and NMR) spectrometers; a chemical instruments laboratory with infrared and ultraviolet spectrophotometers, an atomic absorption spectrophotometer, gas and liquid chromatographic equipment, and a vapor-phase osmometer; and a chemical dynamics laboratory with equipment for investigating photochemistry, rapid reaction kinetics, and chemical synthesis.

PHYSICS

PH 0110 REFRESHER PHYSICS (5-3). A six-week course designed to refresh incoming students in selected basic concepts of mechanics and either thermodynamics or electricity and magnetism. The level of presentation and choice of material depend upon the background and needs of the students. The laboratory sessions are devoted to guided problem-solving.

PH 0111 REFRESHER PHYSICS AND CHEMISTRY (7-3). A six-week refresher course of selected topics from elementary mechanics and chemistry for incoming students who are entering the more quantitative engineering and science curricula. Typical topics from mechanics are kinematics, Newton's laws, the concepts of energy and momentum, and simple harmonic motion. Chemis-

try topics will include atomic structure, the chemical bond, stoichiometry, and chemical equilibrium and kinetics. The use of calculus and vector algebra is emphasized. The three one-hour laboratory period are devoted to guided problem solving. PREREQUISITES: Previous college courses in elementary physics and chemistry and integral calculus.

PH 0119 PHYSICAL SCIENCE REFRESHER (5-3). A non-credit refresher course of 6 weeks' duration designed for the Operational Systems Technology (ASW) curriculum. The course covers particle kinematics and dynamics, the use of coordinate systems and vectors, projectile motion, harmonic motion and the one-dimensional wave equation.

PH 0499 ACOUSTICS COLLOQUIUM (0-1). Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: A course in acoustics.

PH 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

PH 0999 PHYSICS AND CHEMISTRY COLLOQUIUM (0-1). Discussion of topics of current interest and student thesis reports.

Lower Division Courses

PH 1005, PH 1006, and PH 1007 comprise a series of courses intended for students with limited background in mathematics.

PH 1005 ELEMENTARY PHYSICS I (4-2). Mechanics, Heat, and Sound. Lectures, problem sessions, and laboratory. Physical quantities and the concepts of motion, force, momentum, and energy. The mechanics of gases, heat transfer, and thermodynamics. Simple harmonic motion and propagation of sound.

PH 1006 ELEMENTARY PHYSICS II (3-2). Electricity and Magnetism. Electrostatics, electric current, and magnetism. Lectures, problem sessions, and laboratory. PREREQUISITE: PH 1005.

PH 1007 ELEMENTARY PHYSICS III (4-2). Optics and Modern Physics. Lectures, problem sessions and laboratory dealing with geometrical optics, mirrors and lenses. Atomic structure, optical spectra, radioactivity and nuclear structure. PREREQUISITES: PH 1005 and PH 1006.

PH 1011, PH 1012, and PH 2017 comprise a series of courses intended primarily for Engineering Science students with a prior knowledge of calculus.

PH 1011 BASIC PHYSICS I (4-0). Mechanics, Heat, and Sound. Review of Newtonian Mechanics. Conservation laws. Rotational motion. Thermal properties of gases, liquids and solids. Laws of Thermodynamics. Wave motion and propagation of sound. PREREQUISITES: Courses in college physics and college mathematics through calculus.

PH 1012 BASIC PHYSICS II (4-0). Electricity and Magnetism. Electrostatics stressing Gauss' Law and the theory of electric fields and potentials. Alternating current. Electromagnetism. PREREQUISITE: PH 1011.

PH 1015, PH 1016, and PH 2017 comprise a series of courses intended to provide a knowledge of the principles of physics and a scientific background for the study of engineering.

PH 1015 BASIC PHYSICS I (5-3). Mechanics, Heat, and Sound. Lectures, problem sessions, and laboratory. Concepts of force, motion, energy, and momentum; thermal properties of gases, liquids, and solids, and wave motion. PREREQUISITE: One quarter of calculus.

PH 1016 BASIC PHYSICS II (4-3). Electricity and Magnetism. Lectures, problem sessions, and laboratory. Electrostatics, electromagnetism, electrochemistry, and direct and alternating currents. PREREQUISITE: PH 1015.

PH 1041 REVIEW OF MECHANICS AND ELECTRICITY AND MAGNETISM (5-1). First quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. *(The sequence includes PH 1041, 2241, 2641 and 3741.)* The subject matter of this course includes: kinematics, dynamics, conservation laws, electrostatics, Coulomb's and Gauss' laws, electric and magnetic fields, Ampere's and Faraday's laws, capacitance and inductance.

PH 1051 REVIEW OF VECTOR MECHANICS AND INTRODUCTION TO FLUIDS (4-2). Basic concepts of elementary vector mechanics, including: statics, motion in one dimension and in a plane, particle dynamics, energy, momentum, rotational dynamics, elementary properties of fluids; qualitative description of drag phenomena; turbulence and separation. The laboratory sessions are devoted to guided problem-solving. PREREQUISITES: Previous courses in general physics and calculus.

PH 1901 THE NATURE AND STRUCTURE OF PHYSICS I (4-2). The development of ideas and measurement leading from early models of the heavens through Galileo and Kepler to Newton and the Theory of Universal Gravitation. Satellites, natural and artificial. The concepts central to classical mechanics: momentum, kinetic and potential energies; conservation principles. Questions about the nature of light. Wave motion and wave properties of light.

PH 1902 THE NATURE AND STRUCTURE OF PHYSICS II (4-2). Fundamental concepts of electromagnetism and light as electromagnetic radiation. Experiments with light and the crisis of classical physics. Einstein and Relativity; space and time revised, mass-energy equivalence. The question of atomic structure and the quantum interpretation. Properties of atoms, nuclei, and particles. PREREQUISITE: PH 1901.

Upper Division Courses

PH 2017 BASIC PHYSICS III (4-2). Optics and Modern Physics *(PH 2017 is the third course for both the PH 1011, PH 1012, and the PH 1015, PH 1016 series of Basic Physics).* Lectures, problem sessions, and laboratory. Geometrical optics, mirrors and lenses. Interference and diffraction. Special relativity, quantum effects of waves and particles, structure of the hydrogen atom, nuclear structure, and nuclear reactions. PREREQUISITES: PH 1011 and PH 1012 or PH 1015 and PH 1016.

PH 2121 APPLIED PHYSICS I (4-0). The first of a two course sequence, intended for students of Operations Analysis, in which physical phenomena are described and illustrated by their application to situations of military interest. This course considers vibrating systems, resonance, the nature of sound and light, acoustics terminology and hearing, the eye and vision, the ray approximation, the ray treatment of propagation of acoustic and electromagnetic waves, geometric optics, the mathematical description of waves and wave effects including transmission, reflection, standing waves, interference and diffraction.

PH 2122 APPLIED PHYSICS II (4-0). The second of a two course sequence, intended for students of Operations Analysis, in which physical phenomena are described and illustrated by application to situations of military interest. This course considers electromagnetism, sources of electromagnetic radiation, the wave equation, phenomena associated with the interaction of waves and media including scattering and absorbtion, the mathematical description of non-repetitive waveforms, modulation and bandwidth, noise and noise sources, power spectral density, infrared radiation and sources, infrared detectors, infrared systems, radar and sonar systems and the associated figure of merit equations. PREREQUISITE: PH 2121.

PH 2151 MECHANICS I (4-0). Kinematics and dynamics in two and three dimensions. The damped harmonic oscillator. The

gravitational two-body problem. PREREQUISITES: PH 1051, calculus, vector algebra, and ordinary differential equations (the latter may be taken concurrently).

PH 2152 MECHANICS II (4-0). Motion of a system of particles, conservation laws, rigid body motion, rotating coordinate systems, Lagrangian mechanics. Additional topics as time allows: mechanics of continuous media, gravitational potential theory. PREREQUISITE: PH 2151.

PH 2241 WAVE PHENOMENA (4-2). Second quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. This course stresses the generality of wave phenomena drawing examples from optics, radar, acoustics, etc. Harmonic waves, interference, diffraction, wave equation, energy flow, boundary value problems and normal modes, Fourier analysis, Fourier transform, phase and group velocity, geometrical optics. PREREQUISITES: PH 1041 or PH 1051.

PH 2251 WAVES AND PARTICLES (4-2). A course designed to provide the background and fundamental ideas in modern physics which are utilized in atomic, molecular, solid state, and nuclear physics. Wave properties; propagation, interference, diffraction, polarization. Electromagnetic waves. The special theory of relativity. Photoelectric and Compton effects. Wave-particle dualism; de Broglie hypothesis and introduction to the Schroedinger equation; electron diffraction; wave packets. Continuous and line spectra; black-body radiation; hydrogen atom spectrum. PREREQUISITES: PH 1051, MA 2121.

PH 2260 OPTICAL PHYSICS (4-2). A course in the basic ideas of wave propagation and optical phenomena fundamental to many branches of modern physics and technology. Topics will include wave and ray optics, optical instruments, fiber optics, wave propagation, interference, coherence, Fraunhofer and Fresnel diffraction, resolving power, dispersion, birefringence, polarization, radiometry, scattering, blackbody and other radiation sources. Laboratory: The laboratory sessions will be devoted to student performance of exercises designed to complement and illuminate class discussion, and to develop skills and familiarity with optical instrumentation. PREREQUISITES: MA 1100, PH 1051 or equivalent.

PH 2280 NUCLEAR WEAPONS AND FOREIGN POLICY (4-0). An interdisciplinary course which covers both the technology and political influences of nuclear weapons systems. The course will emphasize the interaction of nuclear weapons systems with the foreign policies of the major powers and political blocs from 1945-present. May also be offered as GV 2280 or GV 3280.

PH 2351 ELECTROMAGNETISM I (4-0). Properties of electric and magnetic fields and the development of Maxwell's Equations: electrostatic fields and potential in free space and dielectrics, the magnetic fields and potentials of steady currents in free space and permeable materials, electromagnetic induction, Maxwell's Equations, and Poynting's Theorem. PREREQUISITES: PH 1051 and MA 2161 or equivalent.

PH 2352 ELECTROMAGNETISM II (4-0). Properties of electromagnetic waves: wave equations; propagation of plane waves in free space, dielectrics, conductors, and plasmas; reflection and refraction of plane waves; two-conductor transmission lines; and rectangular wave guides. PREREQUISITE: PH 2351.

PH 2471 PHYSICS OF SOUND I (2-1). The first of a two-part analytical survey of physical acoustics for students in the Operational Systems Technology (ASW) curriculum. This approximately half-quarter long course normally follows OC 2115, taught in the same quarter. Topics include mechanics of simple vibration systems; fundamental properties of waves, acoustic parameters for sound in fluids and reflection and transmission phenomena at plane boundaries between fluids. Laboratory exercises are devoted to familiarization with acoustic instruments and measurements. COREQUISITE: MA 2129.

PH 2472 PHYSICS OF SOUND II (4-2). The second of a two-part analytical sequence for students in the Operational Systems Technology (ASW) curriculum. Emphasis is on ocean acoustics. Topics include developing and solving the acoustic wave equation in an ideal fluid, radiation of sound from a simple source and from one- and two-dimensional arrays, sound absorption, waveguides, ray acoustics, and an introduction to acoustic transducers. A part of this course will be participation in a sonar systems study project. PREREQUISITE: PH 2471. COREQUISITE: MA 3139.

PH 2551 THERMODYNAMICS (3-0). (may be taught as CH 2401). Fundamental theory of thermodynamics and applications to physical systems. First and second laws of thermodynamics; entropy; thermodynamic potentials; applications to gases, liquids, radiation, and magnetic materials; equilibrium. PREREQUISITE: PH 1051 and calculus of several variables.

PH 2552 INTRODUCTION TO THE THERMAL AND DYNAMIC PROPERTIES OF GASES AND LIQUIDS (3-0). Introductory thermodynamics including the First and Second Laws, properties of gases and liquids, basic fluid mechanics including equations of motion in both inertial and non-inertial coordinate systems. This course is designed for the Operational Systems Technology (ASW) curriculum. PREREQUISITES: Courses (may be concurrent) in vector calculus and differential equations.

PH 2641 ATOMIC PHYSICS (4-2). Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Bohr model. Schroedinger equation, exact solution for hydrogen atom, electron spin, periodic table, atomic spectra, transition probabilities, Einstein coefficients and stimulated emission, molecules and molecular spectra. PREREQUISITE: PH 2241 or PH 2251.

PH 2645 MODERN PHYSICS (4-2). Interference, phase and group velocity, wave particle duality, Bohr atom, spectra, 1-dimensional wave mechanics, Schroedinger equation and applications including hydrogen atom, periodic table, spin-orbit interaction, quantum electronic devices. PREREQUISITES: PH 2241 or equivalent, MA 2121.

PH 2810 SURVEY OF NUCLEAR PHYSICS (4-0). A course designed to introduce the student to the ideas of nuclear physics, with emphasis on neutron physics and reactors. Atomic nature of matter; wave-particle duality; the nuclear atom. Basic nuclear properties; reactions, neutrons and fission. Reactors.

PH 2903 PHYSICS AND MODERN DEVICES (3-2). Development of the physical foundations of some recent technological devices of interest to the Naval Officer. The topics will be selected according to the interests of the class and instructor and could include items such as lasers, magnetometers, underwater detection, nucear fission and fusion, solid state electronics. PREREQUISITE: PH 1902 or consent of the Instructor.

Upper Division or Graduate Courses

PH 3154 PHYSICS OF SPACE VEHICLE DYNAMICS (3-0). Basic physical principles are applied to study the trajectories of satellites and missiles: orbits in the inverse-square force field are developed, including the role of initial (launch) conditions, followed by rendezvous problems, transfer between orbits, synchronous satellites, perturbations due to oblateness of the earth. An introduction to launch and re-entry problems is given, including multistage rockets. Advanced propulsion methods. PREREQUISITES: PH 2152 or equivalent mechanics course.

PH 3157 PHYSICS OF CONTINUA (4-0). The continuum hypothesis. Cartesian tensors. The concept of stress. Deformation. Conservation of mass, momentum and energy. Theory of constitu-

tive equations. Applications to fluid mechanics, solid mechanics and wave phenomena. PREREQUISITE: PH 2151.

PH 3161 PHYSICS OF UNDERWATER VEHICLES (4-1). Physical properties of liquids. Solutions to potential flow problems. Viscous flow; the laminar boundary, turbulence, and separation. Cavitation. Special topics may include: hydrodynamic noise, resistance of surface ships, and drag reduction techniques. PREREQUISITES: Vector calculus (e.g., MA 2161), and mechanics (e.g., PH 1051).

PH 3280 ELECTRO-OPTICS (4-2). Refracting systems; atmospheric and underwater transmission, scattering, and scintillation; diffraction and Fourier transform methods; coherent optics, Fourier plane filters, holography; fiber and film optics; electro-optic detectors; infrared techniques; image intensifiers; lasers and applications; nonlinear optics. PREREQUISITE: A course in atomic physics.

PH 3431 PHYSICS OF SOUND IN THE OCEAN (4-2). A survey of physical acoustics with emphasis on the generation, propagation, and detection of sound in the ocean, primarily for students in the Environmental Science and Operations Analysis curricula. Topics include: damped and forced harmonic oscillations; the acoustic wave equation and its limitation in fluids; solutions for plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation in the ocean; effects of inhomogeneities and sound absorption; term by term analysis of the SONAR equations emphasizing transmission loss models and detection threshold models; properties of transducers for underwater sound. Laboratory experiments include surface interference, spectral analysis of noise, normal modes, waveguides, and acoustical sources. PREREQUISITES: A course in general physics and a course in differential equations.

PH 3451 FUNDAMENTAL ACOUSTICS (4-1). Mechanics of free, forced, and damped simple vibratory systems. Mechanical impedance. Development of, and solutions to the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Specific acoustical behavior of the piston source. Radiation impedance. Lumped acoustic elements and propagation in pipes. Steady state response of acoustic waveguides. Group and phase velocities. Normal Modes. Laboratory experiments on selected topics. PREREQUISITES: A course in mechanics (e.g., PH 1051); Differential Equations (e.g. MA 2121).

PH 3452 UNDERWATER ACOUSTICS (4-2). Loudspeakers and microphones. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean: the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems. Laboratory experiments on selected concepts. PREREQUISITE: PH 3451.

PH 3461 EXPLOSIVE SHOCK WAVES (4-0). Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Shock loads on ships and blast loads on structures. Damage mechanism and principles of protection against damage. PREREQUISITES: PH 2551 or CH 2401, and PH 2151 or PH 3451.

PH 3463 SPECIAL TOPICS IN UNDERWATER ACOUSTICS (3-2). A terminal course following PH 3452 for those students who do not pursue a graduate level program. Topics may include additional material in underwater acoustics, transducer theory, nonlinear phenomena in acoustics, explosive waves in water, noise and vibration control. Laboratory experiments on related material. PREREQUISITE: PH 3452 or equivalent.

PH 3471 FUNDAMENTALS OF ACOUSTICS (4-2). The first of a two-part survey of physical acoustics and its applications to underwater sound for students in the Operational Systems Technology (ASW) curriculum. Topics include: mechanics of simple harmonic vibrating systems; development of the acoustic wave equation in fluids; fundamental properties of waves; propagation of plane and spherical waves; reflection and transmission of waves at plane boundaries; radiation of sound from simple sources, from arrays of sources and pistons; waves in enclosed spaces and propagation in simple acoustic wave guides. PREREQUISITES: PH 2552, MA 3139.

PH 3472 UNDERWATER ACOUSTICS (4-2). The second of a two-part sequence for the Operational Systems Technology (ASW) curriculum. Sound absorption phenomena in fluids; sound transmission in the ocean, including effects of boundaries and sound speed gradients; ray acoustics and the Eikonal equation; sound reflection and scattering in the ocean; reverberation and target strength; acoustic noise analysis; signal recognition; the Sonar Equations for active and passive systems and introduction to acoustic transducer. PREREQUISITES: PH 3471 and OC 3265 (may be concurrent).

PH 3561 INTRODUCTORY STATISTICAL PHYSICS (4-0). Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and radiation. PREREQUISITES: PH 2152, PH 2551 or CH 2401, PH 3651.

PH 3651 ATOMIC PHYSICS (4-2). Properties of the electron, the nuclear atom, the Bohr theory of the hydrogen atom, atomic energy levels, the Schroedinger Equation and properties of its solutions, application of the Schroedinger Equation to the square potential well and to the hydrogen atom, angular momentum operator, electron spin, identical particles, the Pauli Principle, multielectron atoms, the Periodic Table, the vector model of the atom and complex spectra, the Zeeman effect, Einstein coefficients and stimulated emission of radiation. PREREQUISITES: PH 2251 and MA 2161 or equivalent.

PH 3652 ELEMENTS OF MOLECULAR, SOLID STATE, AND NUCLEAR PHYSICS (4-2). X-ray spectra and Bragg's law, molecular bonds, excited states of molecules, molecular spectra. Bonding in crystals. Conduction in solids, band theory. Semiconductors. Fundamentals of nuclear physics, radioactivity and the decay law. Interaction of charged particles and photons with matter. PREREQUISITE: PH 3651.

PH 3687 PHYSICS OF ELECTRON INTERACTION IN GASES (3-0). This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer, emission from surfaces, recombination, high frequency and d.c. breakdown, sheaths, the glow and arc discharges, radiation, application to the gas laser. PREREQUISITES: PH 2641 or PH 3651 or consent of the Instructor.

PH 3741 ELECTRONIC PROPERTIES OF METALS AND SEMI-CONDUCTORS (4-2). Fourth quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Crystals and lattice properties, X-ray diffraction, free-electron theory, electrical conductivity, band theory. Brillouin zones, effective mass, holes, intrinsic and impurity semiconductors, diodes, transistors, thermoelectric effects, minority carriers, modern devices. PREREQUISITES: PH 2641 or PH 3651.

PH 3903 SCIENCE, VALUES, AND CULTURE (4-0). The place of science in the modern world is one of the major problems of contemporary life. This course explores the problem through an analysis of the relationship of science to human values and the character of our culture as a whole. Each of the three major phases

of the course deals with an aspect of this relationship. The first traces the background and development of modern science as a phase of Western culture. The second attempts to formulate a viable contemporary approach to the character of scientific inquiry. The third deals with the major philosophical, religious, and moral issues involved in the relation of science and culture in our time. PREREQUISITE: Graduate standing and consent of Instructor. May also be offered as GV 3903.

PH 3951 INTRODUCTION TO QUANTUM MECHANICS (4-0). The general principles of quantum mechanics. Schroedinger equation. Harmonic oscillator. Angular momentum, many particle systems, electron spin, the Pauli exclusion principle. Time independent and time dependent perturbation, and the semiclassical theory of radiation applied to atomic transitions. PREREQUISITES: PH 2351, MA 2161 or equivalent, PH 3651 (may be taken concurrently).

PH 3998 STUDIES IN INTERMEDIATE PHYSICS (2-0 or 4-0). Supervised study in one of the fields of intermediate physics selected to meet the needs of the student. PREREQUISITE: Consent of the Department Chairman.

Graduate Courses

PH 4162 FLUID MECHANICS (3-0). An advanced study of the physical bases of fluid mechanics: Fundamental concepts of continuum mechanics. Fluid mechanical models. Theory of hydrodynamic stability. Lighthill's theory of aerodynamically produced sound. Effects of compressibility. Fluid dynamic discontinuities, shock waves, and the method of characteristics. PREREQUISITE: A course in hydrodynamics (e.g., PH 3161).

PH 4171 ADVANCED MECHANICS (4-0). Hamilton's Principle. The equations of motion in Lagrangian and Hamiltonian form. The inertia tensor and rigid bodies. Canonical transformations and Poisson brackets. Small oscillations. Additional topics as time allows: Hamilton-Jacobi theory, perturbation theory. PREREQUISITES PH 2152, PH 2352.

PH 4281 ELECTRO-OPTIC DEVICES (4-0). Infrared, visible and ultraviolet detectors and their limitations; electron optical devices; scanning devices; image displays and storage techniques; starlight viewing devices; viewing devices for self-luminous infrared sources; optical tracking; lasers and applications; coherent optical information processing and holography; nonlinear optical devices; optical heterodyning; acoustic-optic devices; fiber and film optical devices; optical signal processing and switching. PREREQUISITE: PH 3280 and a corequisite course in solid state physics.

PH 4353 ELECTROMAGNETISM III (3-0). Classical radiation theory: retarded potentials, Lienard-Wiechert potentials, fields of a fast electron, angular distribution and frequency spectrum of radiation from an accelerated point charge, Cherenkov radiation, Hertz potentials and dipole radiation, and radiation from linear antennas. PREREQUISITE: PH 2352.

PH 4371 CLASSICAL ELECTRODYNAMICS (3-0). Tensors in special relativity. Classical relativistic electromagnetic field theory. Lorentz electron theory. PREREQUISITES: PH 4353 and familiarity with the special theory of relativity and Lagrangian Mechanics.

PH 4453 PROPAGATION OF WAVES IN FLUIDS (4-0). An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields, incoherence and coherence; applications of the Helmholtz Integral probability density functions, correlations and frequency spectra of sound scattered from rough boundaries; macrosonics, including nonlinear propagation and shock wave phenomena. PREREQUISITE: PH 3452 or consent of Instructor.

PH 4454 TRANSDUCER THEORY AND DESIGN (3-2). A treatment of the fundamental phenomena basic to the design of transducers for underwater sound and specific examples of their application. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory experiments on measurement techniques, properties of transducer materials and characteristics of typical transducer types. PREREQUISITE: PH 3452 or equivalent.

PH 4455 ADVANCED ACOUSTICS LABORATORY (0-3). Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4456 SEMINAR IN APPLICATIONS OF UNDERWATER SOUND (3-0). A study of current literature on applications of acoustics to problems of naval interest. PREREQUISITE: PH 4453 or consent of instructor.

PH 4571 STATISTICAL PHYSICS I (3-0). Kinetic theory and the Boltzmann theorem, configuration and phase space, and the Liouville theorem, ensemble theory, microcanonical, canonical, and grand canonical ensembles, quantum statistics. PREREQUISITES: PH 2152, PH 3651, PH 2551.

PH 4572 STATISTICAL PHYSICS II (3-0). A continuation of PH 4571 with applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. PREREQUISITE: PH 4571.

PH 4630 SPACE PHYSICS I—PHYSICS OF THE UPPER ATMOSPHERE (4-0). Structure of the upper atmosphere. Atmospheric absorption in the infrared, visble and ultraviolet. The ionosphere. Geomagnetic field and the radiation belts. Disturbances of the upper atmosphere. Magnetic field, the magnetopause and solar wind. Experimental instrumentation in space research. PREREQUISITES: PH 2352 and PH 3652 or consent of the Instructor.

PH 4631 SPACE PHYSICS II—PHYSICS OF THE SOLAR SYSTEM (4-0). Solar interior and surface. Solar magnetic field, sunspots and flares. Emissions from the sun. Introduction to stellar evolution and cosmology. PREREQUISITE: Consent of the Instructor.

PH 4661 PLASMA PHYSICS I (4-0). Introduction to the physical and mathematical concepts fundamental to various branches of plasma physics and space physics such as ionospheric communications, advanced propulsion, and controlled fusion. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The Boltzmann equation and the macroscopic momentum and energy transport equations are discussed. The magnetohydrodynamic and the two-fluid plasma models are considered. PREREQUISITES: PH 2352, PH 3561, PH 3651, or the equivalent.

PH 4662 PLASMA PHYSICS II (3-0). A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the study of macroscopic motions of a plasma. Effect of Coulomb interactions, relaxation times and runaway electrons. Small amplitude plasma waves, shock waves. Radiation from plasmas, including bremsstrahlung and cyclotron radiation. Plasma instabilities. PREREQUISITES: PH 4353, PH 4661 or equivalent.

PH 4681 ADVANCED PLASMA PHYSICS (3-0). Selected topics in plasma physics, such as waves in anisotropic plasmas, turbulence and fluctuations, collisionless shock waves. PREREQUISITES: PH 4662 or consent of the Instructor.

PH 4685 ADVANCED ATOMIC PHYSICS (3-0). Selected topics in atomic spectroscopy and atomic collisions. Classical and quantum description of the collision process, transition probabilities and line broadening mechanisms. PREREQUISITES: PH 3651 and consent of the Instructor.

PH 4750 RADIATION EFFECTS IN SOLIDS (5-0). The effects of nuclear radiation and the effects of shock waves on the properties of solids: interaction of radiation with solids, displacement of atoms in solids and the effects on solid state properties; effects on electrons in the solids; effects of shock compression of solids, behavior beyond the elastic limit, phase changes. PREREQUISITES: PH 3461, PH 3561, PH 3652.

PH 4760 SOLID STATE PHYSICS (4-2). Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. PREREQUISITE: PH 3651 and PH 3561 (the latter may be taken concurrently.)

PH 4790 THEORY OF QUANTUM DEVICES (3-0). Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, internal fields: application to specific electronic devices, parametric amplifiers, magnetic instruments. PREREQUISITES: PH 2641 or PH 3651.

PH 4851 NUCLEAR PHYSICS I (4-2). Nuclear decay schemes and energetics; nuclear forces; the deuteron and low energy nucleon-nucleon scattering; partial wave analysis of scattering; neutron-induced reactions and the Breit-Wigner formula; nuclear fission and fusion; nuclear reactors. PREREQUISITES: PH 3652, PH 3951 and PH 2352.

PH 4881 ADVANCED NUCLEAR PHYSICS I (3-0). Selected topics in nuclear and particle physics. The particular subjects covered will depend on the needs of the students and choice of the Instructor. PREREQUISITES: PH 4851 and PH 3951 or PH 4971.

PH 4882 ADVANCED NUCLEAR PHYSICS II (3-0). A continuation of PH 4881. PREREQUISITE: PH 4881.

PH 4885 REACTOR THEORY (3-0). The diffusion and slowing down of neutrons. Homogeneous thermal reactors; time behavior; reactor control. Multigroup theory. Heterogeneous system. PREREQUISITE: PH 3652.

PH 4971 QUANTUM MECHANICS I (3-0). General principles of nonrelativistic quantum mechanics. Stationary states of the square well, the harmonic oscillator, and the hydrogen atom. PREREQUISITES: PH 3651 and PH 4171.

PH 4972 QUANTUM MECHANICS II (3-0). Addition of angular momenta. Time-independent and time-dependent perturbation theory. Scattering theory. Identical particles and spin. PREREQUISITES: PH 4971.

PH 4973 QUANTUM MECHANICS III (3-0). General principles of relativistic quantum mechanics. Properties and solutions of relativistic wave equations. PREREQUISITES PH 4371 and PH 4972.

PH 4981 QUANTUM FIELD THEORY I (3-0). General principles of quantum field theory. Quantization of scalar, spinor, and electromagnetic fields. PREREQUISITE: PH 4973.

PH 4982 QUANTUM FIELD THEORY II (3-0). Interacting fields. The S-matrix and renormalization. Strong, electromagnetic, and weak interactions. Introduction to dispersion relations. PREREQUISITE: PH 4981.

PH 4991 RELATIVITY AND COSMOLOGY (3-0). Einstein's general theory of relativity. The three classical tests. The Schwarzschild singularity and black holes. Cosmological models and their relations with observations. Introduction to modern developments: gravitational waves, Dicke's theory, problems of quantum cosmology and superspace. PREREQUISITE: PH 4371.

PH 4993 PHYSICAL GROUP THEORY (3-0). Invariance of quantum mechanical systems to certain groups of transformations. Topics to be selected from finite rotation groups and crystal symmetries, the continuous rotation group in three dimensions, transformation groups associated with elementary particle symmetries. PREREQUISITE: PH 4972.

PH 4998 READING IN ADVANCED PHYSICS (2-0 to 4-0). Supervised reading in one of the fields of advanced physics selected to meet the needs of the student. May be repeated for credit in a different field. PREREQUISITE: Consent of the Instructor.

PH 4999 ADVANCED SEMINAR (1-0 to 3-0). A seminar in recent developments in basic and applied physics, conducted by faculty members with student participation. PREREQUISITE: The student should have graduate standing and the consent of the Instructor.

CHEMISTRY

Lower Division Courses

CH 1001 INTRODUCTORY GENERAL CHEMISTRY I (4-2). The first quarter course of a two quarter sequence for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter.

CH 1002 INTRODUCTORY GENERAL CHEMISTRY II (3-2). The second quarter of a two-quarter sequence for students who have not had chemistry before coming to the Postgraduate School. PREREQUISITE: CH 1001.

Upper Division Courses

CH 2001 GENERAL PRINCIPLES OF CHEMISTRY (3-2). A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter and chemical equilibria. Special attention is given to the compounds of carbon. Elementary physical chemistry experiments are performed in the laboratory. PREREQUISITE: College Chemistry.

CH 2051 APPLICATION OF PHYSICAL CHEMISTRY (4-0). The course includes background material related to lasers, electro-optics, remote detection, and environmental problems. Topics studied include atomic and molecular structure, energy levels, chemical kinetics and relaxation processes, instruments for molecular sensing, separation, and identification, chemical equilibrium, thermodynamics, and environmental chemistry. PREREQUISITE: PH 1051.

CH 2101 INORGANIC ANALYSIS (3-3). A continuation of CH 2001. Computations involving acid-base, solubility, and complex ion equilibria. Principles of quantitative analysis. Descriptive inorganic chemistry. Laboratory work will consist of gravimetric and volumetric analysis. PREREQUISITE: CH 2001 or CH 1002.

CH 2102 INORGANIC CHEMISTRY (3-3). Redox reactions and the electrode potential. Introduction to reaction mechanism. Bonding in inorganic species. Acids and bases. Laboratory will make use of qualitative, semi-quantitative, and instrumental methods to study the principles further, especially as applied to the solution chemistry of the metals. PREREQUISITES: CH 2101 and CH 2402.

CH 2201 CHEMICAL INSTRUMENTS (3-3). A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. PREREQUISITES: CH 2101 and Ch 2403.

CH 2301 ORGANIC CHEMISTRY I (4-3). The first quarter of a two quarter study of the chemistry of organic compounds. PREREQUISITE: CH 2402 (May be taken concurrently.).

CH 2302 ORGANIC CHEMISTRY II (3-3). A continuation of CH 2301. The study of Organic Chemistry is pursued further with emphasis in the laboratory on synthetic techniques. PREREQUISITE: CH 2301.

CH 2401 CHEMICAL THERMODYNAMICS (3-0). The laws of thermodynamics and their applications to chemical systems. Use is made of the chemical potential in describing multicomponent systems and the conditions for thermodynamic equilibrium. PREREQUISITE: Differential Equations.

CH 2402 PHYSICAL CHEMISTRY I (3-3). Further applications of thermodynamics to chemical systems, colligative properties, chemical equilibrium, chemical kinetics, and electrochemistry. PREREQUISITE: CH 2401.

CH 2403 PHYSICAL CHEMISTRY II (4-3). Introduction to quantum chemistry, molecular structure, crystals, statistical mechanics, and reaction rate theory. PREREQUISITE: CH 2402.

CH 2910 INTERACTION OF NAVAL OPERATIONS AND ENVIRONMENTAL POLLUTION (4-0). An interdisciplinary course which examines the impact of environmental pollution on Naval operations by examining current technical status, future plans for abatement and the resultant limitations placed on Naval facilities, especially ships. The course will consider air, water, nuclear, and noise pollution or its potential for pollution as appropriate. PREREQUISITES: Math through college algebra. Two quarters of physical science or biology within the last two years is desirable.

Upper Division or Graduate Courses

CH 3101 ADVANCED INORGANIC CHEMISTRY (3-3). Coordination compounds and crystal field theory. Inorganic reaction mechanisms. The laboratory introduces the student to general methods for investigating chemical reaction. PREREQUISITES: CH 2102, CH 2403.

CH 3301 PHYSICAL ORGANIC CHEMISTRY I (3-0). First quarter of a two-quarter sequence. In this term the tools available for the study of organic mechanisms are discussed and appropriate examples used. PREREQUISITES: CH 2302, CH 3101.

CH 3402 PHYSICAL CHEMISTRY IN ORDNANCE SYSTEMS (4-2). A course in topics of special interest to students in Ordnance Engineering. Thermochemistry, chemical equilibrium, chemical kinetics, electrochemistry. Applications will include problems in explosives and propellants, corrosion, fuel cells, remote sensors, and environmental effects. The laboratory will amplify the lecture material especially through the use and study of chemical instruments. PREREQUISITE: PH 2551; a previous course in chemistry.

CH 3403 CHEMICAL THERMODYNAMICS (3-0). Application of thermodynamics to real gases, non-electrolytes, electrolytic solutions, multicomponent solutions. Calculations of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and other molecular data. PREREQUISITE: CH 2402.

CH 3405 MOLECULAR DYNAMICS (5-0). Direct application of the Schroedinger wave equation to the hydrogen atom, angular momentum, matrix formulation of quantum mechanics, electron spin, the Pauli principle, interaction with electromagnetic radiation, development of group theory and application in quantum mechanics, and application of preceding framework to molecular hybridization, molecular orbital theory, ligand field theory, and vibrational spectra. PREREQUISITES: CH 2403, Matrix algebra.

CH 3415 STATISTICAL MECHANICS (4-0). A general treatment of the principles of quantum and classical statistical mechanics with applications to chemical systems. Included are distribution laws and the relationships of Fermi-Dirac, Bose-Einstein, and corrected Boltzmann statistics; statistical entropy and thermodynamic functions for corrected Boltzmann statistics; applications to chemical equilibria, diatomic and polyatomic molecules including ortho and para hydrogen; canonical and grand canonical ensembles; real gases. PREREQUISITE: CH 2403.

CH 3709 EXPLOSIVES CHEMISTRY (3-2). Chemical and physical properties of explosives are related to modes of behavior and physical principles of use. Basic principles of testing and evaluation of explosives. Trends in new developments are surveyed. Independent exploratory work in the laboratory in such areas as manner of initiation, sensitivity, brisance, power, heats of explosion and combustion. PREREQUISITE: CH 2001.

Graduate Courses

CH 4302 PHYSICAL ORGANIC CHEMISTRY II (3-0). The techniques discussed in CH 3301 are used in the study of organic reaction mechanisms as currently understood. PREREQUISITE: CH 3301.

CH 4406 QUANTUM CHEMISTRY (3-0). A study of molecular spectra and molecular electronic structure, emphasizing theory, interpretation, and prediction of spectra utilizing the quantum mechanical formulation. PREREQUISITE: CH 3405.

CH 4410 CHEMICAL KINETICS (3-0). Experimental methods and interpretation of data. Collision theory and activated-complex theory. Mechanisms of reactions. PREREQUISITE: CH 2403 and consent of Instructor.

CH 4505 RADIATION CHEMISTRY (3-0). A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. PREREQUISITE: CH 2403 or the equivalent.

CH 4800 SPECIAL TOPICS (2-0 to 4-0). Pursuit of deeper understanding of some topic chosen by the student and the instructor; may involve directed reading and conference or a lecture pattern. May be repeated for credit with a different topic. Typical topics are listed as follows:

(1) Chemical Engineering Kinetics
Chemical engineering applications with emphasis on large scale equipment design.

(2) Heat Transfer
Chemical engineering applications with emphasis on large scale and unusual equipment design.

(3) Natural Products
Study of degradation and synthesis of steroids, alkaloids and terpenes.

(4) Advanced Organic Chemistry
Study of new synthetic approaches in depth.

(5) Photochemistry
Chemical processes resulting from the interaction of electromagnetic radiation with matter.

(6) Inorganic Reaction Mechanisms
Theory and experiment concerning mechanisms of substitution and redox reaction for inorganic systems.
PREREQUISITE: Consent of the Instructor.

OTHER COURSES

Upper Division or Graduate Course

BI 3850 BIOLOGICAL EFFECTS OF RADIATION (5-0). This course treats the effects of radiation on individual living cells and

on the whole mammalian organism, including man. Sufficient biological background material is presented, for an understanding of the radiation effects. Aspects of radiological safety are also treated. PREREQUISITES: PH 3652 and PH 2551.

SE 2001 through SE 4006 is a series of courses specifically designed for students in the Naval Intelligence Curriculum (825).

Upper Division Courses

SE 2001 CONCEPTS OF ENVIRONMENTAL SCIENCE (4-0). Studies will be made of environmental processes in both the atmosphere and the ocean that provide input to intelligence decision making. Sources of data, terminology and channels of data transmission will be discussed as well as the general reliability of environmental data. PREREQUISITE: None.

SE 2002 CONCEPTS OF SCIENCE & ENGINEERING I (4-0). The first of a two-course sequence designed to prepare an advanced student with a non-quantitative and non-technical background for the study of advanced technology systems. The course is staffed jointly by the Department of Physics & Chemistry and the Department of Electrical Engineering. Topics include: linear systems modeling and characteristics, spectral analysis, wave properties and wave phenomena, and computer systems. PREREQUISITE: Mathematics including an introduction to differential and integral calculus.

SE 2003 CONCEPTS OF SCIENCE & ENGINEERING II (4-0). A continuation of SE 2002. Topics include: photography and photogrammetry, communication systems, signal processing, and control systems. PREREQUISITE: SE 2002.

Upper Division or Graduate Courses

SE 3004 SURVEY OF MILITARY TECHNOLOGY: CONCEPTS AND APPLICATIONS I (4-0). This is the first of a two-course sequence designed to familiarize the student with the conceptual basis of military applications of technology and to trace developments in these areas through current R & D efforts. The sequence is taught by the departments of Aeronautics, Electrical Engineering, Mechanical Engineering, Oceanography, and Physics and Chemistry, and is coordinated by the Department of Physics and Chemistry. In this course the following topics will be treated: radar systems, communication systems, electronic surveillance systems, and electro-optic systems. PREREQUISITES: SE 2003 or equivalent, and SECRET clearance (NOFORN).

SE 3005 SURVEY OF MILITARY TECHNOLOGY: CONCEPTS AND APPLICATIONS II (4-0). This is the second of a two-course sequence designed to familiarize the student with the conceptual basis of military applications of technology and to trace developments in these areas through current R & D efforts. In this course the following topics will be treated: acoustic surveillance systems, selected topics in aeronautical and Naval engineering, missile systems, satellite systems, and strategic systems. PREREQUISITES: SE 2003 or equivalent, and SECRET clearance (NOFORN).

Graduate Course

SE 4006 SPECIAL TOPICS IN TECHNOLOGY ASSESSMENT (4-0). Methods by which the technological capabilities of a nation, either current or future, will be assessed. Problems in source evaluation, cross-impact analysis, and trend extrapolation. Delphi studies and their role. As a part of this seminar the student will make a detailed study and report on the methodology and results of a current technology assessment study. PREREQUISITES: SE 3004, SE 3005.

Herrmann Hall, the main administration building

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

ISHAM WISEMAN LINDER, Rear Admiral, U.S. Navy, Director; B.S., U.S. Naval Academy, 1946; M.S.E.E., Naval Postgraduate School, 1956; Ph.D., University of California at Berkeley, 1961.

HERMAN PAUL ECKER, Professor; Executive Director (1957)*; B.A., Pomona College, 1948; M.A., Claremont Graduate School, 1949; Ph.D., 1967.

JOHN EDWARD DAWSON, Professor; Deputy Executive Director (1966); B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954; D.P.A., 1971.

IVON WILLIAM ULREY, Professor; Assistant Director, Research and Program Development (1966); B.S. Ohio State Univ., 1931; M.B.A., New York Univ., 1937; Ph.D., Ohio State Univ., 1953.

SHERMAN WESLEY BLANDIN, Jr., Associate Professor; Assistant Director, Academic Programs (1968); B.S., Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953; M.B.A., Univ. of Santa Clara, 1973.

ROBERT MOFFAT ALLAN, Jr., Professor (1971); B.A., Stanford Univ., 1941; M.S., Univ. of California at Los Angeles, 1942.

ROBERT MAURICE BERG, Major, U.S. Air Force; Assistant Professor (1971); B.S., South Dakota State Univ., 1958; M.B.A., Ohio State Univ., 1967.

ROBERT EDWARD BOYNTON, Associate Professor (1970); B.A., Univ. of Minnesota, 1956; M.A., 1962; Ph.D., Stanford Univ., 1968.

LEWIS RUSSELL CABE, Major, U.S. Army, Assistant Professor (1972); B.S. North Carolina State Univ., 1961; M.A., Univ. of Alabama, 1970; Ph.D., 1971.

JAMES FREDERICK CALLAHAN, Lieutenant Commander, U.S. Navy; Assistant Professor (1970); B.S., Univ. of Pennsylvania, 1960; M.S., Naval Postgraduate School, 1970.

DAVID RUSSELL CAMPBELL, Lieutenant Commander, U.S. Navy; Assistant Professor (1973); B.S., Univ. of New Mexico, 1963; M.S. Naval Postgraduate School, 1973.

WILLIAM AYERS CAMPBELL, Associate Professor (1970); B.S., Tuskegee Institute College, 1937; M.S.I.M., Univ. of Pittsburgh Graduate School, 1949.

FRANK ELMER CHILDS, Professor (1965); B.A., Willamette Univ., 1934; M.B.A., Univ. of Southern California, 1936; Ph.D., Univ. of Minnesota, 1956.

JOHN MORSE COOK, Lieutenant Commander, SC, U.S. Navy; Assistant Professor (1973); B.A., Princeton Univ., 1959; M.S., Naval Postgraduate School, 1968.

BRUCE HOWARD DeWOOLFSON, Jr., Major, U.S. Marine Corps; Assistant Professor (1973); B.A., Pennsylvania State Univ., 1942; M.S., Naval Postgraduate School, 1970.

EDWARD JOSEPH FREED, Assistant Professor (1972); B.S. Boston College, 1966; M.B.A., Wharton School of Finance and Commerce, Univ. of Pennsylvania, 1968.

CHARLES GILBERT LEATHERS, Visiting Associate Professor (1973); B.A., Central State College, 1964; M.A., Univ. of Oklahoma, 1966; Ph.D., 1968.

WILLIAM ALAN MAUER, Professor (1966); A.B., San Jose State College, 1955; M.S., Agricultural and Mechanical College of Texas, 1957; Ph.D., Duke Univ., 1960.

BURTON ROSS PIERCE, Visiting Associate Professor (1973); B.A., Harvard Univ., 1956; M.B.A., 1962; Ph.D., Stanford Univ., 1971.

NORMAN PLOTKIN, Assistant Professor (1969); B.S., Univ. of California at Los Angeles, 1948; B.F.S., Georgetown Univ., 1950; M.S., Claremont Graduate School, 1966; Ph.D., 1969.

CARL MAYNARD PON, Ensign, U.S. Naval Reserve; Instructor (1973); B.A., Univ. of California at Los Angeles, 1972.

ALEXANDER WOLFGANG RILLING, Captain, U.S. Navy; Assistant Professor (1972); B.A., Rensselaer Polytechnic Institute, 1951; M.S., Naval Postgraduate School, 1962; Ph.D., Univ. of Southern California, 1972.

ROBERT LYNN RITTENOURE, Assistant Professor (1973); B.A., Kansas State Univ., 1965; M.A. Univ. of Texas, 1967; Ph.D., 1970.

RICHARD EDWARD SAUNDERS, Commander, U.S. Navy: Assistant Professor (1971); B.S., Naval Postgraduate School, 1967; M.S., 1970.

ROBERT von PAGENHARDT, Professor (1967); A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., 1970.

ROBERT DONALD WALDO, Associate Professor (1972); B.S., Univ. of Colorado, 1948; M.S., 1949; Ph.D., Claremont Graduate School, 1972.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

The Navy Management Systems Center established as a separate Naval Activity in February 1966 is a jointly staffed DoD sponsored activity. As of 1 July 1974 the name was changed to Defense Resources Management Education Center. It conducts both resident and on-site defense resource management courses for U.S. and foreign military personnel of all services in grades 0-4 and above and military-related civilians of equal grades. The focus of all programs conducted by the Center is on the development of knowledge and improvement of understading of the concepts, techniques and application of modern defense management systems, with specific emphasis on effective resource management.

The Center currently offers a four-week U.S. Defense Management Systems Course eight times each year, a one-week Flag/General Defense Management Course twice each year, and a thirteeen-week International Defense Management Course

twice each year, plus a four-week Senior International Defense Management Course one time each year (similar to the 13-week international course but contracted). Mobile training teams are available on request and assistance has and is being presented to cooperating foreign countries and international agencies in the general area of defense management.

In addition to the DoD programs, the Center is currently involved in presenting management programs on-site to the service components and selected state governments.

Since 1966, the Center has graduated nearly 6,500 students.

Faculty members of the Center are a part of the regular faculty of the Postgraduate School.

DEFENSE MANAGEMENT SYSTEMS COURSE

The Planning-Programming-Budgeting System has developed since 1961 by the Office of the Secretary of Defense has provided a framework for examining varous force mixes, allocation of resources, and relationships to military capabilities.

The objective of the Defense Management Course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of management, including requirements studies, systems analysis cost/effectiveness, cost estimating and analysis.

Students are not expected to become experts or technicians in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analyses for decision-making, understanding of the principles, methods and techniques used, and awareness of the interfaces between management and requirements of the Department of Defense components and the Office of the Secretary of Defense.

Quotas to the Defense Management Systems Course are controlled by the sponsoring agency: i.e., the Departments of Army, Navy, Air Force, and the Office of the Secretary of Defense.

FY 75 Schedule RESIDENT COURSES

75-1R	8 Jul–4 Oct 74	IDMC
75-2R	8 Jul–2 Aug 74	DMSC
75-3R	5 Aug–30 Aug 74	DMSC
75-4R	2 Sep–27 Sep 74	DMSC
75-5R	10 Oct–17 Oct 74	F/G
75-6R	21 Oct–15 Oct 74	DMSC
75-7R	2 Jan–28 Mar 75	IDMC
75-8R	6 Jan–31 Jan 75	DMSC
75-9R	3 Feb–28 Feb 75	DMSC
75-10R	3 Mar–28 Mar 75	DMSC
75-11R	3 Apr–10 Apr 75	F/G
75-12R	21 Apr–16 May	DMSC
75-13R	2 Jun–27 Jun 75	SIDMC

A similar schedule is planned for FY 76

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961-1965	1966-1970	1971	1972	1973	Total
Bachelor of Arts	.....	.....	.....	180	389	78	91	77	815
B. S. in Aeronautical Engineering	73	212	212	181	61	12	3	.....	754
B. S. in Chemistry	.....	.....	3	3	4	4	5	.....	19
B. S. in Engineering Acoustics	.....	.....	.....	.....	.....	.....	.....	1	1
B. S. in Communications Engineering	.....	.....	42	95	45	.....	.....	.....	182
B. S. in Electrical Engineering	62	115	98	253	182	33	42	40	825
B. S. in Engineering Electronics	94	177	92	172	81	.....	.....	.....	616
B. S. in Engineering Science	.....	.....	.....	.....	141	41	38	29	249
B. S. in Environmental Science	.....	.....	.....	12	.....	.....	.....	.....	12
B. S. in Management	.....	.....	.....	53	1	.....	.....	.....	54
B. S. in Mechanical Engineering	43	116	52	82	53	4	9	3	362
B. S. in Meteorology	16	104	77	108	49	13	3	5	375
B. S. in Operations Research	.....	.....	.....	.....	49	26	11	15	101
B. S. in Physics	.....	15	36	75	35	8	1	2	172
Bachelor of Science	.....	56	94	583	259	39	57	42	1,130
Total Baccalaureate Degrees	288	795	706	1,797	1,349	258	260	214	5,667
M. S. in Aeroelectronics	.....	.....	.....	4	3	.....	.....	.....	7
M. S. in Aeronautical Engineering	.....	.....	.....	36	112	33	57	51	289
M. S. in Chemistry	.....	.....	16	5	32	5	6	5	69
M. S. in Communications Engineering	.....	.....	.....	.....	11	.....	.....	.....	11
M. S. in Computer Science	.....	.....	.....	.....	34	32	33	26	125
M. S. in Computer Systems Management	.....	.....	.....	.....	181	92	48	50	371
M. S. in Electrical Engineering	7	34	46	86	267	53	71	86	650
M. S. in Engineering Acoustics	.....	.....	.....	.....	13	9	4	6	32
M. S. in Engineering Electronics	68	120	78	104	40	.....	.....	.....	410
M. S. in Management	.....	.....	.....	406	633	230	212	191	1,672
M. S. in Management/Data Processing	.....	.....	.....	22	66	.....	.....	.....	88
M. S. in Material Science	.....	.....	.....	5	9	.....	.....	.....	14
M. S. in Mechanical Engineering	20	36	48	49	99	24	39	18	333
M. S. in Meteorology	23	19	40	53	53	16	32	23	259
M. S. in Oceanography	.....	.....	.....	.....	119	51	44	31	245
M. S. in Operations Research	.....	.....	.....	63	305	120	120	138	746
M. S. in Physics	.....	25	104	135	124	23	33	13	457
Master of Science	.....	17	65	102	56	6	5	8	259
Total Master's Degrees	118	251	397	1,070	2,157	694	704	646	6,037
Aeronautical Engineer	.....	.....	.....	4	33	3	22	6	68
Electrical Engineer	.....	.....	.....	.....	40	12	8	18	78
Mechanical Engineer	.....	.....	.....	.....	6	3	7	3	19
Doctor of Philosophy	.....	.....	1	14	25	2	9	4	55
Total Degrees	406	1,046	1,104	2,885	3,610	972	1,010	891	11,924

GRADUATES OF THE NAVAL POSTGRADUATE SCHOOL 1972

CERTIFICATE OF COMPLETION

AERONAUTICAL ENGINEERING (Common Core)

WRIGHT, Vernon E., LT, USN

COMMUNICATIONS MANAGEMENT

CLINE, Robert N., LCDR, USN

COMPUTER SYSTEMS MANAGEMENT

VAN PHAN, Pham, LCDR, Vietnamese Navy

ELECTRICAL ENGINEERING

CHARLES, David M., LCDR, USN

ENGINEERING SCIENCE

BURKE, Michael E., LCDR, USN
GILL, Gary E., LCDR, USN
LUGO, Frank J., LCDR, USN
OXENRIDER, Eugene LeRoy, LT, USN
SKOOG, Mark C., LT, USN

METEOROLOGY

URBANEK, Keith A., LCDR, USN

ACADEMIC DEGREES

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

BLEKICKI, Walter C., LT, USN
COLEMAN, John B. Jr., LT, USN
MAMBO, Eduard, LCOL, Indonesian Navy

BACHELOR OF SCIENCE WITH MAJOR IN AERONAUTICS

BATES, Kenneth S. Jr., LT, USN
CORDREY, Robert E., LT, USN
DAVIS, George H. Jr., LCDR, USN
MILLWARD, John E., LT, USN

BACHELOR OF SCIENCE WITH MAJOR IN BUSINESS ADMINISTRATION

BRATSCH, Roger D. J., LT, USN
BRIGGS, Robert J., LT, USN
BRYANT, James H., LCDR, USN
COFFEY, William M., LT, USNR
DONAHUE, John C., LT, USN
ERMIS, Leroy C., CDR, USN
FIELDS, Billy J., LCDR, USN
FISHER, Gary C., LCDR, USN
FOX, Robert E., LT, USN
GRAHAM, Robert F., CDR, USN
HOLIWAY, Weldon Y., LTJG, USN
HOLLAND, Donald R., LT, USN
HUNEYCUTT, Herbert K., LCDR, USN
JOHNSON, Edward M., LCDR, USN
JOHNSON, Thomas L., LCDR, USN
JONES, Edward A., LT, USN
NORDSTROM, Louis W., LT, USN
RASMUSSEN, Paul D., LCDR, USN
SCHEWE, Norman L., LT, USN
SMITH, Stanley A., LT, USN
VALENTY, Patrick P., LT, USN
WALLACE, James J., LCDR, USN

BACHELOR OF SCIENCE IN CHEMISTRY

BARNABY, Kenneth A., LCDR, USN
BROWN, George R., LCDR, USN
NICHOLSON, Edwin P., LCDR, USN
ONER, Yakup, LTJG, Turkish Navy
WARNER, Kenton D., LT, USN

BACHELOR OF SCIENCE WITH MAJOR IN COMPUTER SCIENCE

ADAMS, Robert C., CDR, USNR
BACON, Robin L., CDR, USNR
BEST, William V., CDR, USNR
DEARING, Paul W., CDR, USNR
GRAHAM, Robert E., CDR, USNR
HINKLE, James L., LCDR, USN
HOFFMAN, Royal H. Jr., LT, USN
LUPTON, William L., LT, USN
McLEOD, Samuel D. Jr., LCDR, USN
MELLBERG, Kenneth E., LCDR, USNR
NICHOLSON, Herbert H. J., CDR, USN
PAWLAS, Robert W., LT, USN
SECADES, Vincent C., LCDR, USN
SKINNER, CHARLES A., LT, USNR
TURINGAN, Felix L., LTJG, Philippine Navy
WHITE, Bernard G., LCDR, USN

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

BALL, Robert H., LT, USN
BOBADILLA, Juan M., LT, Spanish Navy
BURGESS, Larry L., LT, USN
CANTALAPIEDRA, Julio, LT, Spanish Navy
CAPEWELL, John Jr., LCDR, USN
CLARK, Thomas A., LT, USN
CRAIG, Norman L., LCDR, USN
EDDICKS, Ingo H., CDR, Federal German Navy
EYICEOGLU, Ahmet, LTJG, Turkish Navy
FISEK, Gultekin, LTJG, Turkish Navy
GARAU, Pedro J., LT, Spanish Navy
GOESCHEL, Georg W., LCDR, Federal German Navy
HADJICONSTANDIS, Anthony C., LCDR, Hellenic Navy
HARRIMAN, Robert B., LCDR, USN
IMAROM, Prathuang, LCDR, Royal Thai Navy
KAISER, David G., LCDR, USN
KORAL, Nejat, LTJG, Turkish Navy
LEE, David C., LT, USNR
MOGOLLON, Manuel A., LTJG, Colombian Navy
MEEK, Calvin, LT, USN
MONTERO, Angel J., LT, Spanish Navy
NUALPRASERT, Boon J. Rit, LCDR, Royal Thai Navy
ORTH, Gerhard M., LCDR, Federal German Navy
OZDEMIR, Behlul, LTJG, Turkish Navy
PALOUBIS, John, LT, Hellenic Navy
PHILLIPPI, Frederick E. Jr., LCDR, USN
PRICKETT, Frederick G., LT, USN
PRUNSCH, Heinz R. P., LT, Federal German Navy
RODRIGUEZ, Francisco, LT, Spanish Navy
ROMERO, Edgar V., LTJG, Colombian Navy
SADLER, Clint D., LT, USN
SAENZ, Juan, LTJG, Equadorian Navy
SARZETAKIS, Theodoros, LT, Hellenic Navy
SEZGINCI, Ozcan, LTJG, Turkish Navy
SOUCHON, Lennart, LCDR, Federal German Navy
UNLU, Osman, LTJG, Turkish Navy
WAGNER, Tod W., LT, USN
WATKINS, Paul V. Jr., LT, USN
WATT, Phillip A., LT, USN
WILSON, Henri E., MAJ, Indonesian Navy
ZIMMERMANN, Wolff-Ruediger, LT, Federal German Navy
ZORRILLA, Erasmo, LT, Peruvian Navy

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

AMANN, Lawrence S., LT, USN
BAGGETT, Donald W., LT, USNR
BAKHSHANDEHPOUR, Manochehr, LT, Imperial Iranian Navy
BECK, Victor, LCDR, USN
BOCK, Carl F., LT, USN
BOYLE, Patrick L., LCDR, USN
CHRISTIANSEN, Michael P., LT, USN
COGSWELL, Thomas M., LCDR, USN
CRANE, Stephen H., LT, USN
CROWDER, Kenneth L., LCDR, USN
EDWARDS, Brian A., LT, USN
HARRELD, Roger A., LT, USN
ISHERWOOD, Raymond T., LCDR, USN
KEARNEY, Michael E., LT, USN

KROPF, Wallace L., LT, USN
LANE, John W., LCDR, USN
LOWELL, Bobbie R., LT, USN
MADDOCKS, Ronald J., LCDR, USN
MARSYLA, Edward G., LT, USNR
MATHESON, Peter D., LT, USN
MAUGERI, Peter J., LT, USN
MITTELL, John E., LT, USN
NEWMAN, Roger L., LCDR, USN
OZTURK, Yusuf, LTJG, Turkish Navy
PHILLIPS, Robert F. H., LCDR, USN
PRATER, James, CDR, USNR
RASHLEY, George E., CDR, USNR
RICHMOND, Steven A., LT, USN
SALAS ROMER, Leopoldo, CDR, Venezuelan Navy
SCHMIDT, Clifford B., LT, USN
TINCHER, Edward S., LT, USN
WARREN, Fred V., LT, USN
WATTS, McCoy C., LT, USN
WEBBER, Michael J., LCDR, USN
WILEY, Armando A., LT, USN
WILSON, Melvin A., LT, USN
WOLFGANG, Earl D., LT, USN
ZARGARY, Abdollah, LT, Imperial Iranian Navy

BACHELOR OF ARTS

ALLEN, Donald G., LT, USN
ATHANSON, John W., LT, USN
BANKSON, Rodney A., LCDR, USN
BATTERBY, Robert E., LCDR, USN
BLUM, Brandon B., CDR, USN
BOND, William D., LT, USNR
BOUGHTON, Louis C., LCDR, USN
BROOKS, Charles E., LCDR, USN
BRYANT, James C., LCDR, USN
BUFFKIN, Charles R., CDR, USNR
BURNS, William F., LCDR, USNR
BURTCH, Patrick J., LT, USN
CALLIES, Lee R., LT, USN
CAUDLE, Norman E., LT, USN
CLARK, Barbara L., LT, USN
CLEMENGER, John W., LCDR, USN
CLOUTIER, Adore H., LCDR, USN
COLOHAN, William J., CDR, USNR
CUPPER, Terrance A., LT, USN
DAGE, Jerry D., CDR, USN
DAVIS, Robert J., CDR, USNR
DE ST CROIX, Lawrence E., LT, USN
DILL, Donald L., LCDR, USN
DINGER, Robert S. Jr., LT, USN
DURKIN, Wallace M., LCDR, USN
EDWARDS, Robert C., LT, USN
ELLISON, Charles L., LT, USNR
FOWLER, George M., CDR, USNR
GILROY, John W. Jr., CDR, USN
GRAFF, Dennis T., LCDR, USN
GREENWELL, William M., LT, USN
HANNA, Donald V., LCDR, USN
HARRELL, Joe W., LT, USN
HINDS, James J., LT, USN
HOUGH, Howard A., LT, USN
HUBBARD, Clarence H., LCDR, USN
HUNT, Clark H., LCDR, USN
HUSHAW, Walter D., CDR, USNR
JACANIN, James M., LCDR, USN
JACKSON, Milton Jr.,LCDR, USN
JANUARY, Paskell D., LT, USN
JENKINS, James A., LT, USN
JOHNSON, Richard L., LCDR, USN
KALIN, Robert E., LCDR, USNR
KARLISCH, Manfred, LT, USN
KAUP, Robert C., LCDR, USN
KELLY, Robert T., LT, USN
KINLAW, Howard M., LT, USN
KRAL, Jeffrey C., LT, USN
KUHLKE, Robert E., LCDR, USN
LASHER, William J. Jr., LT, USN
LAUER, John N., LCDR, USN
LECROPANE, Richard R., CDR, USNR
LOPEZ, Thomas J., LT, USN
LOWE, Larry T., CDR, USN
LYNCH, Edward T. Jr., LCDR, USN
MACOMBER, David B., LCDR, USN
MARCINKO, Richard, LCDR, USN
MARR, William T., LCDR, USN
McBETH, Dan C., LCDR, USNR
McCALLUM, James A., LCDR, USN
McCLESKEY, Dale L., LTJG, USN
McCORD, Dennis M., LCDR, USN
MESERVE, Theodore J., LT, USN
MEZZADRI, Francis X., LCDR, USN
NELSON, Bruce R., LCDR, USN
NICHOLAS, Joseph, CDR, USN
NORRIS, Lewis H., LT, USN
OLSEN, Kenneth A., LCDR, USN
ONSLOW, Vincent L., LCDR, USN
PAYTON, James E., LT, USN
PEREZ, Demetrio J., LCDR, USN
POTOSNAK, Joseph E., CDR, USN
QUERY, William C. Jr., CDR, USNR
QUINN, Jeffrey, LT, USN
RAINEY, Daniel L., LT, USN
RICE, William L., CDR, USN
SHERRY, James F., LCDR, USNR
SIMERLY, Glen E., CDR, USN
STEPHENSON, Raymond L., LT, USNR
STEPHENSON, Robert F., LCDR, USN
STOUTAMIRE, Stoney L., LT, USN
STRONG, Bradley S., LT, USN
TAIT, William J., LCDR, USNR
THORNTON, Peter C., LT, USNR
VOLD, Almer C., LCDR, USN
WEED, John W., CDR, USN
WEICHMAN, Denis R., CDR, USN
WESENBERG, Wm. W., LCDR, USNR
WILKINS, Stephen V., LCDR, USN
YOUNG, Robert A., CDR, USN

BACHELOR OF SCIENCE WITH MAJOR IN MATHEMATICS

ALBERG, Donald J., CDR, USN
BOWDEN, Newman F. Jr., LT, USNR
FRICK, Frederick M., LCDR, USN
GILFILLAN, Larry G., LT, USNR
PERKINS, Allen D., LT, USN
SAYLOR, William H., LT, USN

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

CRABBE, Douglas V. Jr., LCDR, USN
D'ALESSIO, Fernando, LT, Peruvian Navy
McABEE, John T., LCDR, USN
MORENO, Juan Jose Bonilla, LCDR, Venezuelan Navy
MOUTSATSOS, Panagiotis, LT, Hellenic Navy
RUAN, Miguel G., LCDR, Colombian Navy
TOPOROSKI, Daniiel M., LT, USN
URQUHART, Wiley B. III, LT, USNR
WALKENFORD, John H. III, LCDR, USN

BACHELOR OF SCIENCE IN METEOROLOGY

McDIARMID, James E., LCDR, USN
SAUL, Joe M., LT, USN
TURCZYN, Daniel W., LCDR, USN

BACHELOR OF SCIENCE WITH MAJOR IN OCEANOGRAPHY

BILLINGS, Leland R., LT, USN
DELCOUR, Charles P., LT, USNR
HASENBAUER, Richard D., LT, USN
HARSANYI, William S., LT, USN
JONES, David M., LT, USN
SHEWELL, Daniel J., LT, USN
THORSEN, Paul A., LT, USN
UJLAKI, Michael Jr., LT, USN
WIANT, Jeffrie E. Jr., LT, USN

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

ARAMKUL, Viechei, CPT, Royal Thai Air Force
BECKHAM, Kenneth J., LCDR, USN
BIXLER, Paul W., LT, USN
CHARNSOMRUAD, Moragot, MAJ, Royal Thai Air Force
CUMMINS, Clarence M., CDR, USN
FREAS, Henry E., LT, USN
GROVES, Floyd A., LT, USN
KO, Jung U., CPT, Republic of Korea Army
METKARUNCHIT, Treepet, LT, Royal Thai Army
PRICE, Dennis J., CDR, USN
SUTHIBOON, Smoothara, CPT, Royal Thai Air Force

BACHELOR OF SCIENCE IN PHYSICS

WEBER, Steven D., LT, USN

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

BAILEY, David L., LT, USN
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Colonel Gerald P. Carr, USMC, who served as CAPCOM for Apollo 8 and 12 flights, and was commander of Skylab-4.

Captain Eugene A. Cernan, USN, who was on Gemini 9 mission, was lunar module pilot of Apollo 10 mission, and space commander for Apollo 17.

Lieutenant Colonel Jack R. Lousma, USMC, who served as pilot of Skylab-3.

Captain Edgar D. Mitchell, USN, who was lunar module pilot on Apollo 14.

All four of these astronauts studied in Aeronautical Engineering.

King Hall with Spanagel Hall in the background

Spanagel Hall with breezeway to King Hall Auditorium

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